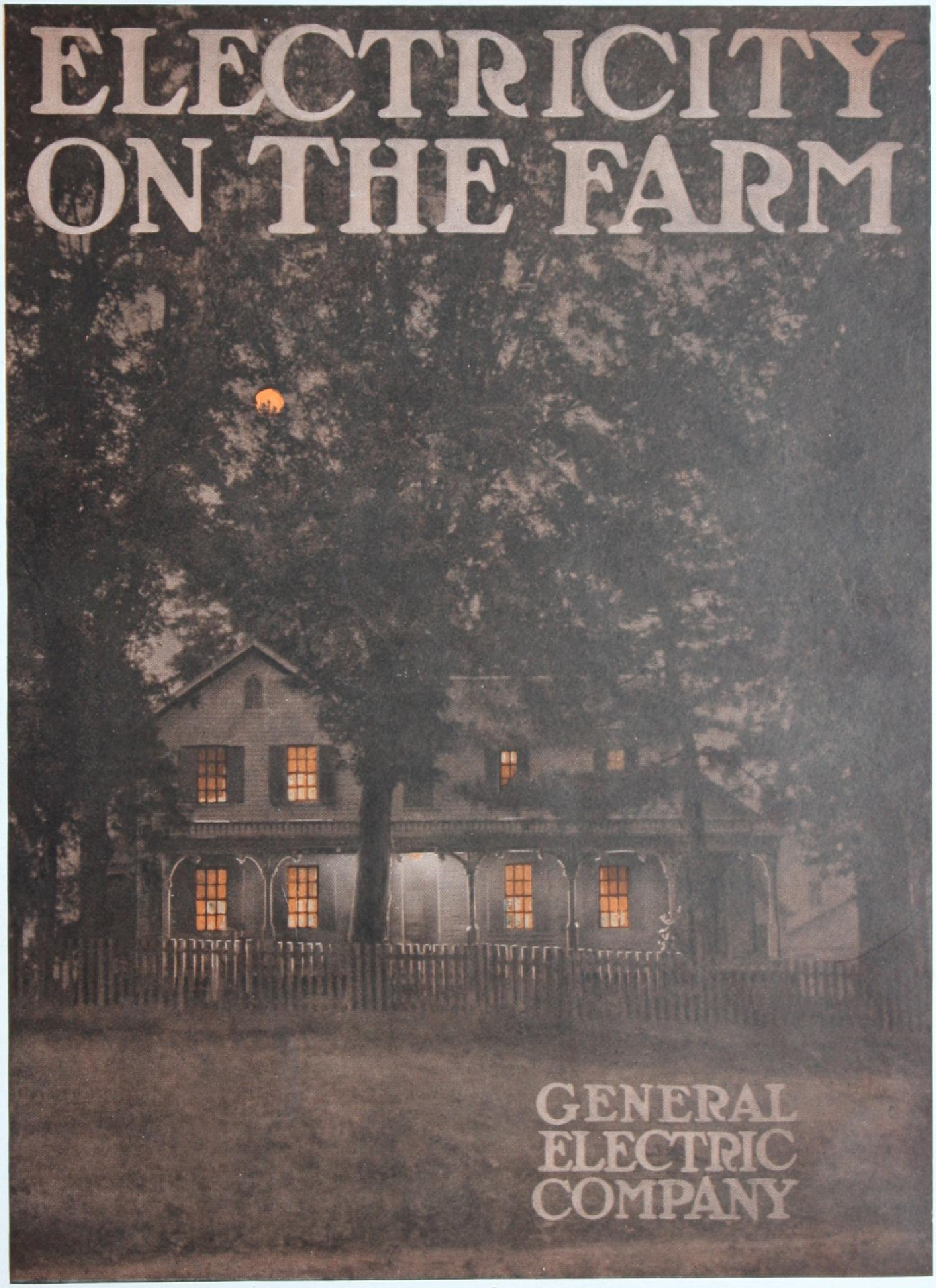
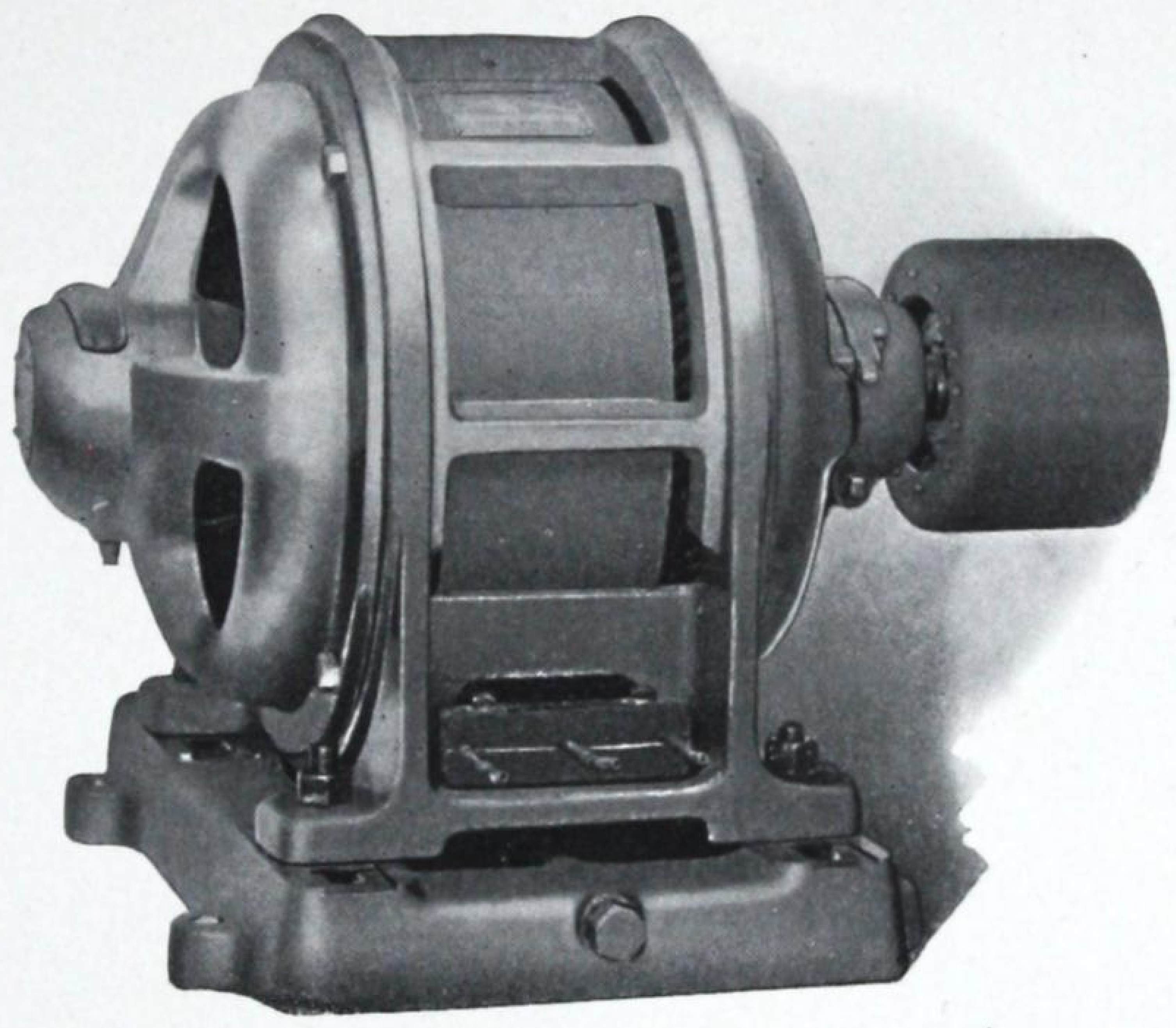
ELECTRICITY ON THE FARM



GENERAL ELECTRIC COMPANY

Electricity on the Farm



Alternating Current Polyphase Induction Motor

General Electric Company

Schenectady, N. Y.

September, 1913 *No. A4115

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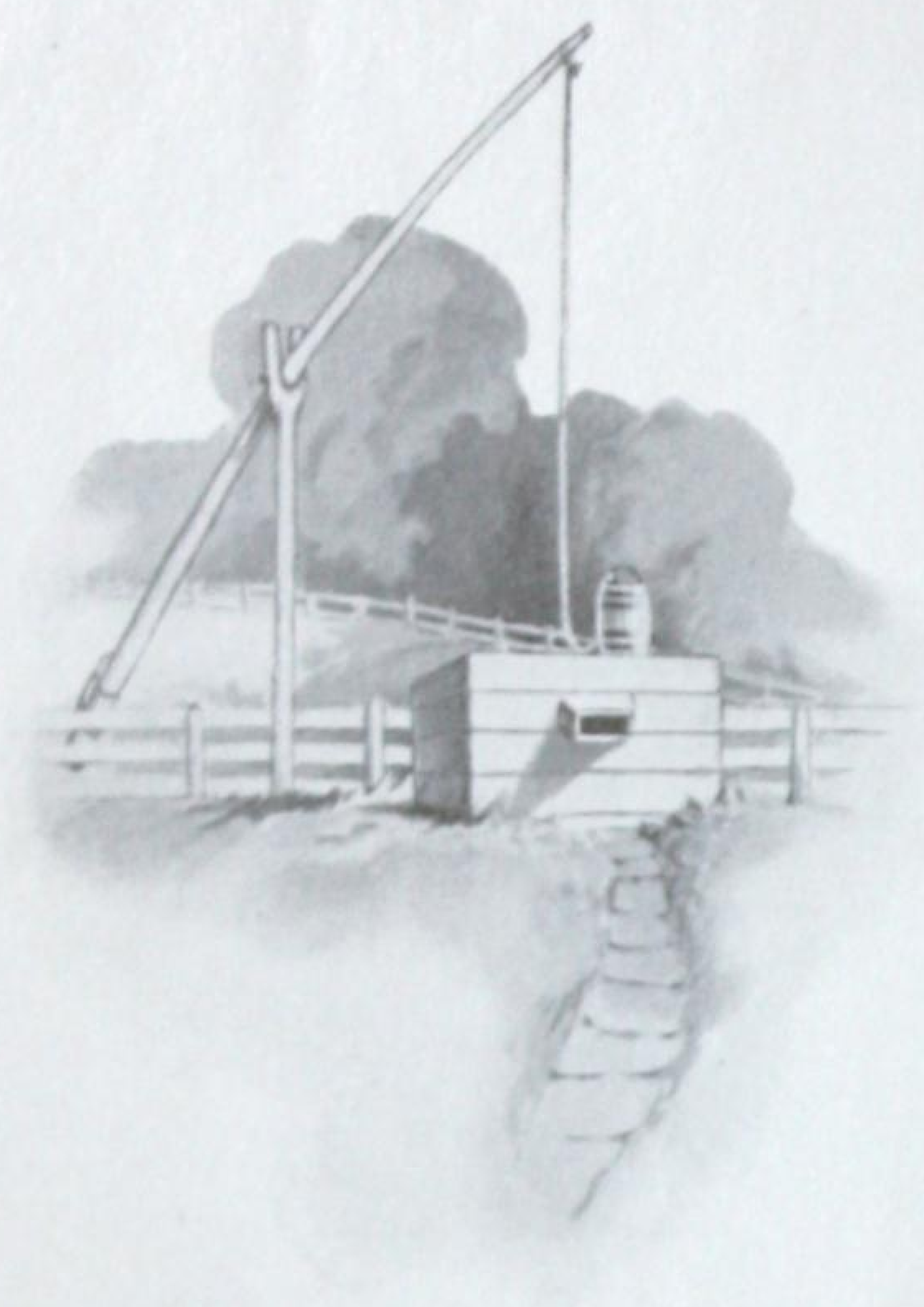
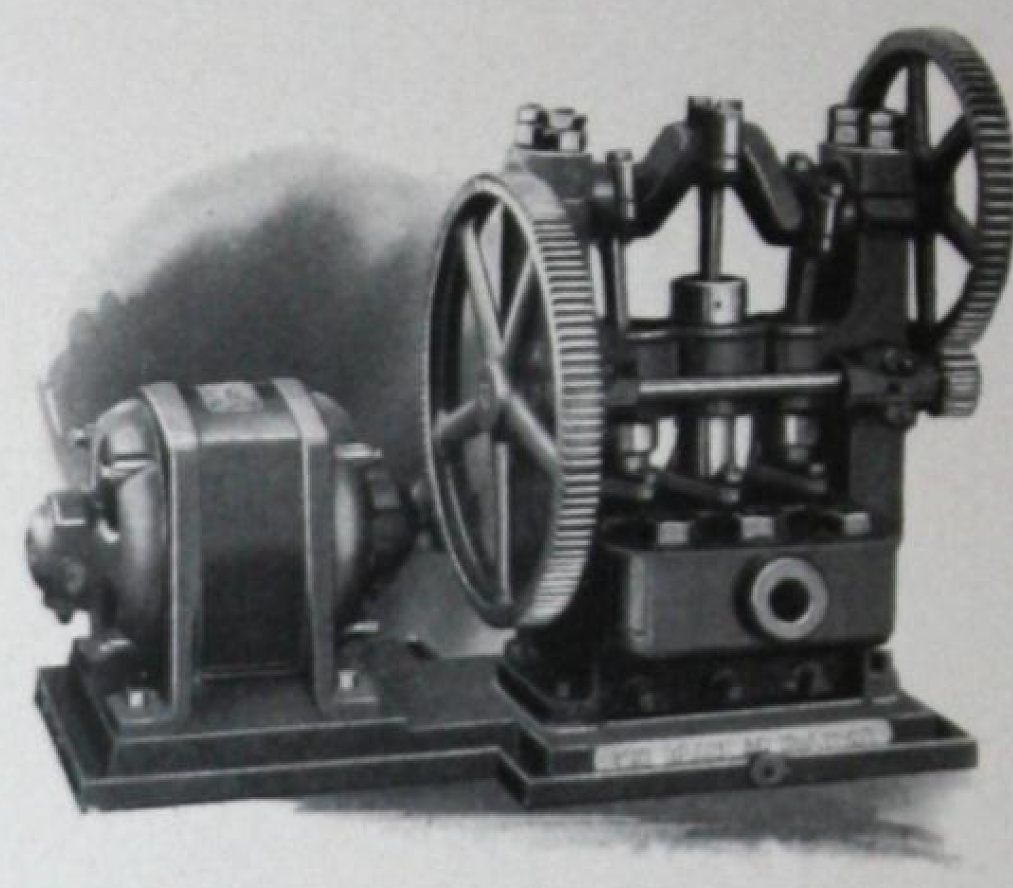
**Supersedes No. 4830.*

Introduction

The prosperity of any nation is dependent largely upon the condition of its agricultural development. It has been estimated that there were never more than 400,000 Indians in North America, but in spite of the enormous per capita acreage available, they were often in want of food; due to their crude and inefficient methods of tilling the soil. Today, by means of the improved methods and widespread adoption of agricultural machinery, this same area easily supplies food for a population of 90 million.



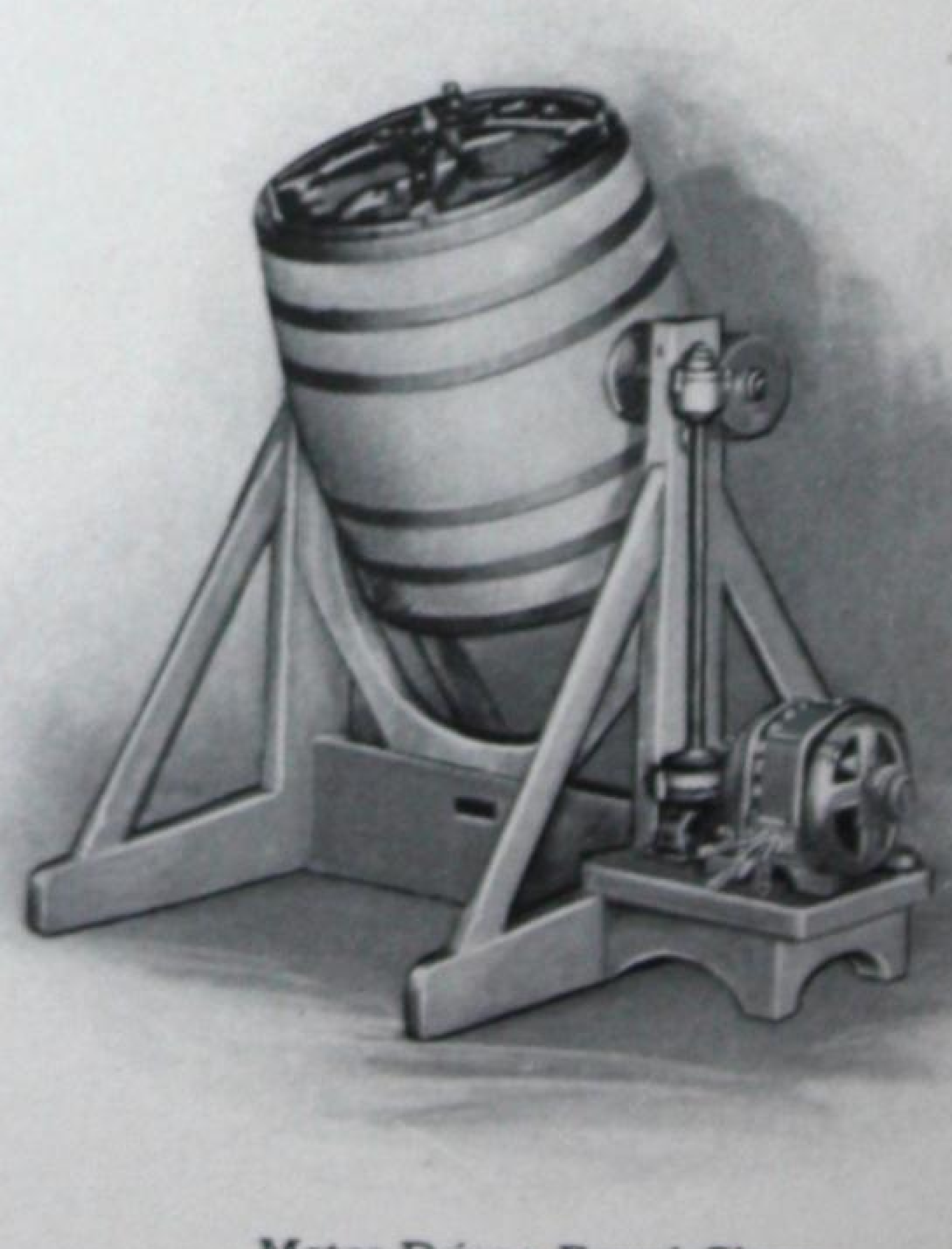


Motor-Driven Triplex Pump

Since the dawn of history man has devised various implements to aid him in reducing the manual and animal labor involved in farm work. Until very recently, however, these implements were of crude construction, and as a consequence the amount of labor required of the farmer for a given output was very great, and his working hours were necessarily long. This condition continued to exist with very slight modifications until about 1850, at which time the general change from hand to machine methods began. In the 12th census report the following statement is made:

"The year 1850 practically marks the close of the period in which the only farm implements and machinery other than the wagon, cart and cotton gin, were those which, for want of a better definition, were called implements of hand production."

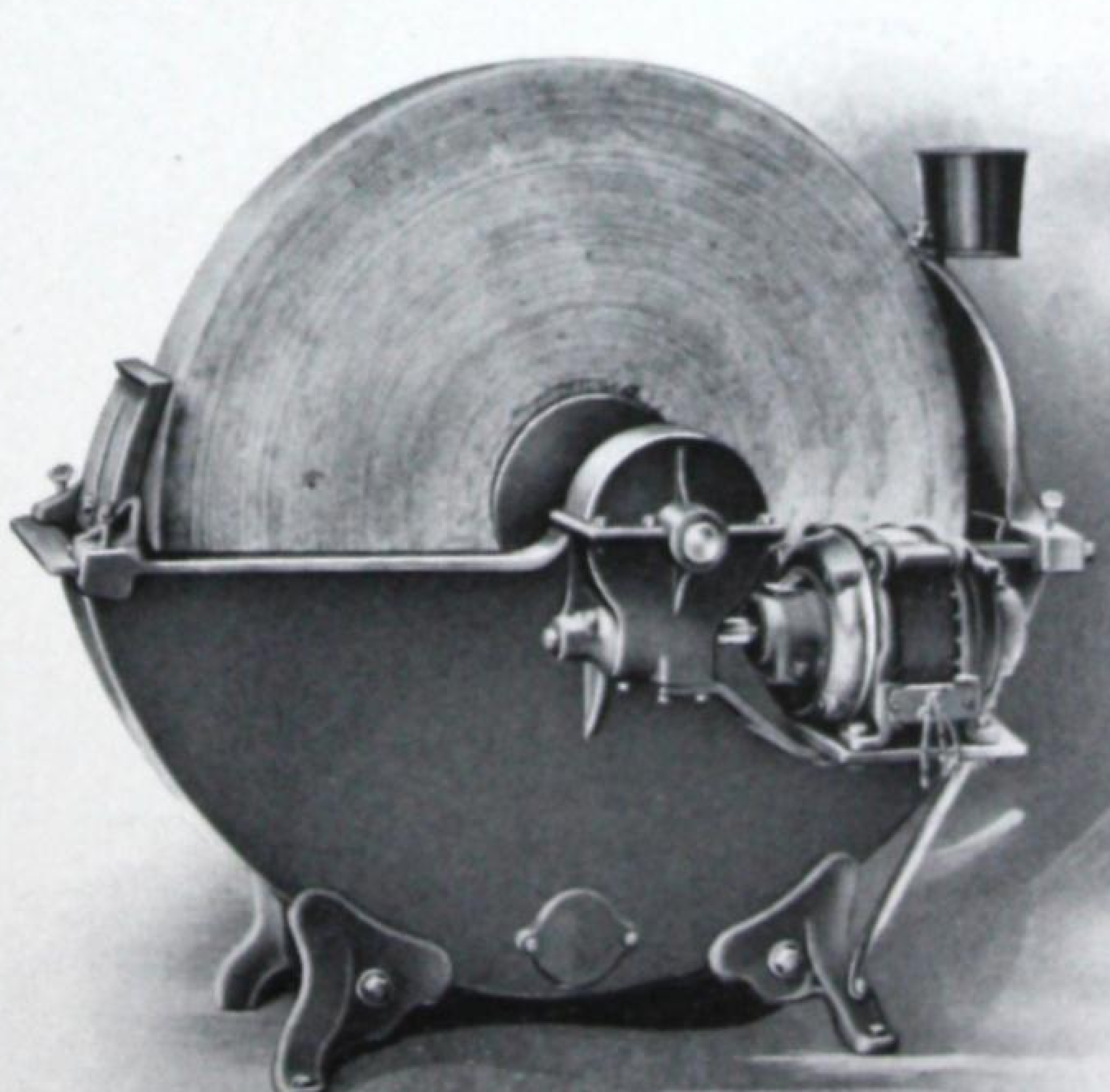
Since then the successive years have seen consistent improvement in the design and manufacture of



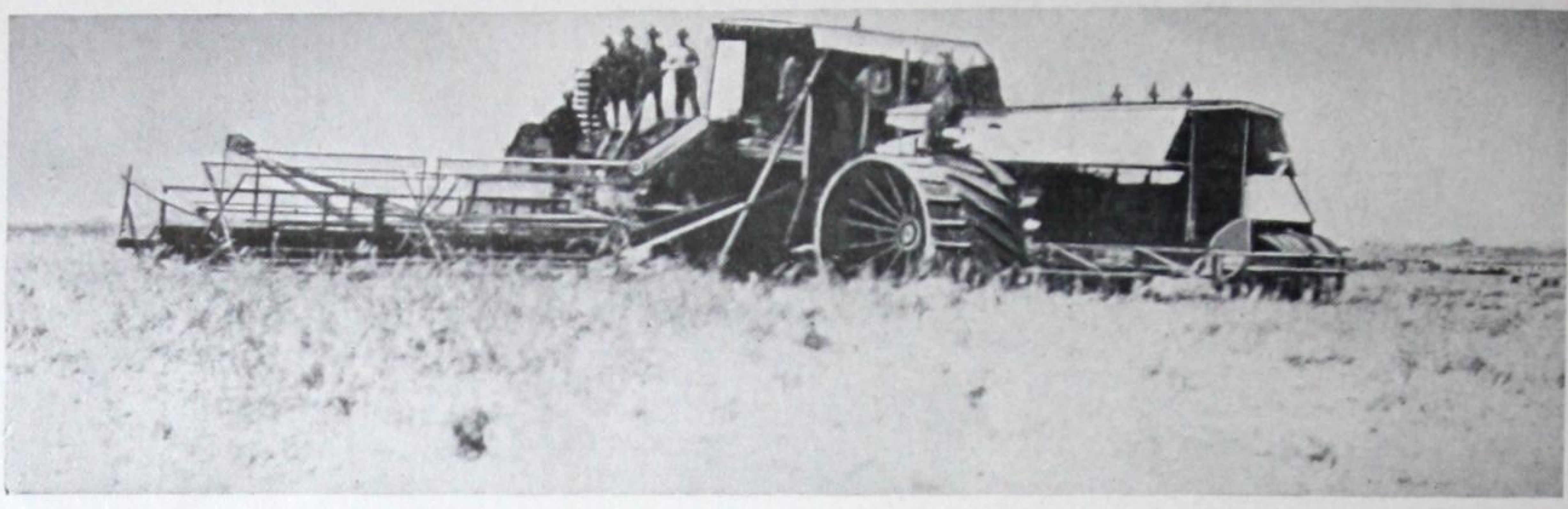
Motor-Driven Barrel Churn

agricultural power machinery, and its adoption on farms of appreciable size has been practically universal. The substitution of machinery for hand and animal labor has resulted in many notable reductions in both time and cost of producing and handling the output of the farm. For instance, the time required to produce a bushel of wheat has been reduced from an average of three hours and three minutes, at a cost of twenty cents, to nine minutes and eighteen seconds, at a cost of ten cents. In 1855, four hours and thirty-four minutes labor was required to produce a bushel of corn, while in 1894 the average time was reduced to forty-one minutes. In the year book of the Department of Agriculture (1899), it is stated that it formerly required 11 hours of manual labor to cut and cure a ton of hay, whereas the same work is today accomplished with the aid of machinery in one hour and thirty-nine minutes, the labor cost being reduced from eighty-three and one-third cents to sixteen and one-quarter cents per ton.

Not only has the use of farm machinery reduced the cost of farm products, but it has also been an aid in improving their quality, due to the more scientific methods of



Motor-Driven Grindstone



Gas-Electric Harvester

planting and harvesting which it has rendered possible. The increasing adoption of machinery is due to a realization of both its efficiency and economy when compared with manual and animal labor, combined with the growing difficulty of obtaining sufficient competent help on American farms.

Accurate data collected by the United States Government shows that the average farm horse does not work more than three hours per day, and that the labor thus performed costs approximately eight cents per hour. It is obvious that almost any form of mechanical power is cheaper than this.

The latest development in power application to farm machinery is electric drive which is readily adaptable to practically every type of farm machine used today, and thousands of farmers throughout the United States are now using the electric motor for power purposes with entire success.

The power and lighting companies all over the country realize the immense business which is before them in rural communities, and today these companies are rapidly extending their lines into farming territory and giving the farmer light and power which are available at an instant's notice, 24 hours per day. Not only this, but many farmers are also using heating and cooking devices which are operated by electric current.

Electric current is not a luxury as many seem to think, and a careful reading and study of the following pages will demonstrate that electricity can and will meet conditions better than any other form of light and power.

Electricity is usually measured and sold by the kilowatt-hour.

The kilowatt-hour (kw-hr.) is equivalent to 1 1/3 h.p. working for a period of one hour. The kilowatt (kw.) is further divided into watts; 1000 watts equal to 1 kilowatt (kw.). Lamps are usually rated in watts. A 40 watt Mazda lamp (about 32 candle-power) will consume 40 watt-hours of electric energy in one hour. At 10 cents per kw-hr, this would mean a cost of 4 mills ($0.004) per hour. 746 watts are equivalent to 1 h.p.

Electric Lighting on the Farm

It is now generally recognized that electricity furnishes the safest, cleanest, most effective and most convenient system of artificial lighting. It is especially valuable for use in farm houses, stables and barns, where there is always danger of fire when oil, acetylene or gas lamps are used; a large percentage of the fire losses in rural communities being due to the use of oil lamps and other dangerous illuminants.

Electric lamps consume no oxygen, and therefore do not vitiate the air. They require no matches and burn without flame, soot or smoke, and are entirely safe, there being no danger of fire even if the lamps are broken. Their use eliminates the work of filling,

100 Watt 80 Candle-power Mazda Lamp Lighting Barnyard on Illinois Farm

cleaning and trimming of oil lamps, and the danger of explosion inherent in the use of oil lamps.

Electric lights are the acme of convenience—by simply turning a switch, light is produced. There is no danger of lights blowing out, and the lamps in any of the buildings or yards may be controlled from a distance by suitably located switches. The electric system is not affected by extremely cold weather, as in the case of gas.

Due to the development of the G-E MAZDA lamp the lighting of farm buildings, yards, and roadways can now be accomplished very economically where electric current is available, as Mazda lamps not only give a light which is much superior to the earlier forms of incandescent carbon lamps, but produce three times as much light for a given consumption of current. The light from these lamps is almost a pure white, and does not produce the ghastly appearance so noticeable with gas mantles or acetylene lamps.

Every Nook in the House Can Be Brilliantly Lighted

Kerosene Lamps are no Longer Necessary in the Living Room

Glen-Sanders House, Scotia, N. Y., Lighted by G-E Mazda Lamps

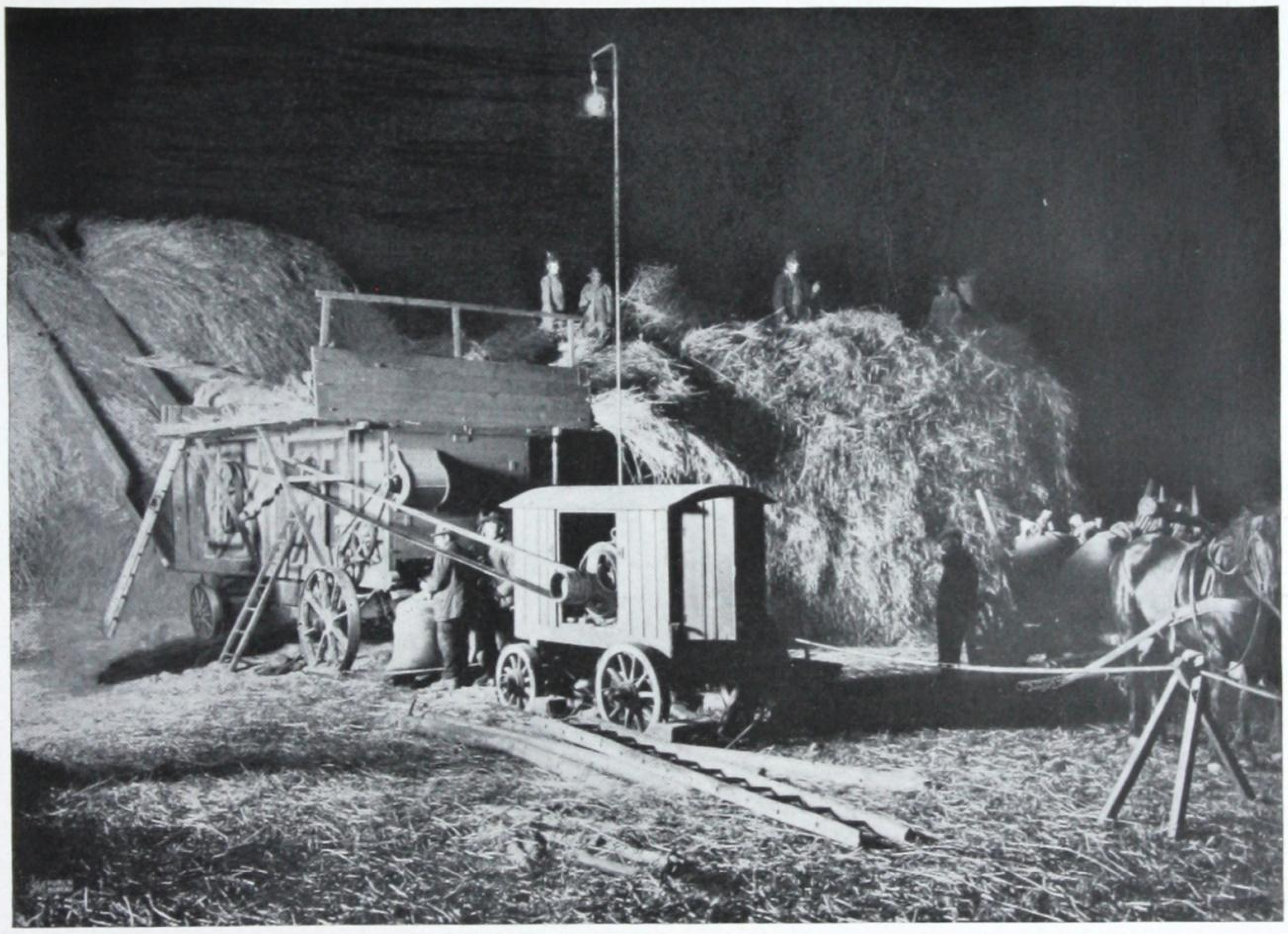
Adequate Light is a Necessity in the Parlor

Brilliant Illumination Alone Makes an Old House New

For the lighting of yards or other large areas highly efficient arc lamps are now available, and for outside illumination on farms the G-E luminous arc and flaming arc lamps are especially adapted.

The necessary wiring for a lighting system can be easily installed, and, as many of the electric household devices require only a small amount of current for their operation, they can be conveniently connected to the incandescent lighting sockets.

The electric lamp can be readily adapted to portable use by attaching it to a long cord and placing the lamp in a G-E Portable Lamp Guard in order to prevent breakage. This portable lamp can be used wherever a lamp socket is available.



Portable Motor Outfit Driving Thresher in the Field and Provided with a Lighting Equipment for Night Work

Electric lighting can be successfully adapted to work in the field; harvesting and threshing being carried on at night as effectively as by daylight.

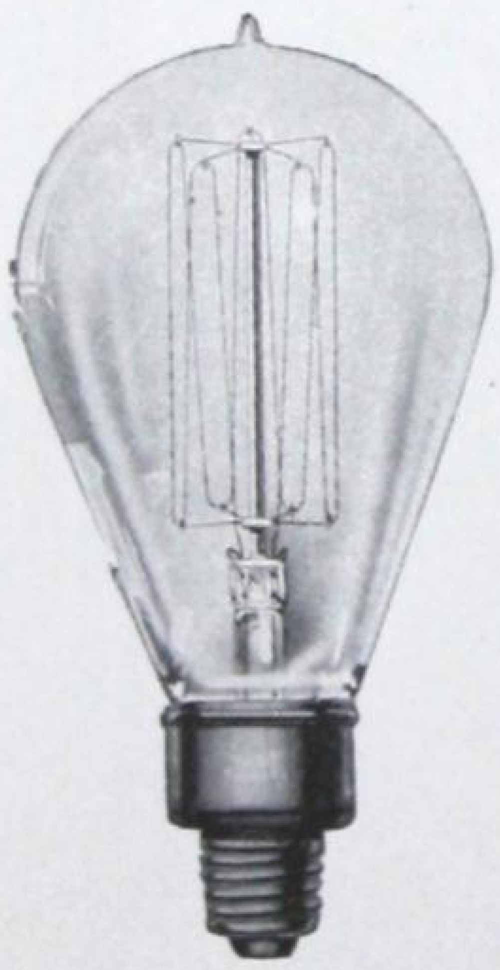
Guards for Portable Incandescent Lamps

Stock Farm of F. U. Daughmer, Douglas, Ill. Mr Daughmer has Electric Service on this 160 Acre Farm. His Installation Consists of Sixteen Incandescent Lamps and an Electric Flatiron. The Complete Equipment Cost Him $25. He Gets Electric Current from The Elmwood Electric Co., Six Miles Away

G-E Mazda Lamps

Rated Watts	Candle-Power	*Hours
20	15	5
25	20	4
40	32	2.5
60	48	1.7
100	82	1

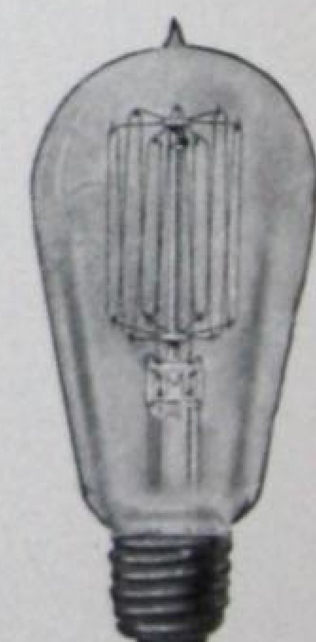
* Number of hours the lamps can be used at a cost of one cent for electricity (at 10 cents per kilowatt-hour).



100 Watts
100-125 Volts

60 Watts
100-125 Volts

40 Watts
100-125 Volts



25 Watts
100-125 Volts

Regular G-E Mazda Lamps One-Quarter Size

Electricity in the Farm Home

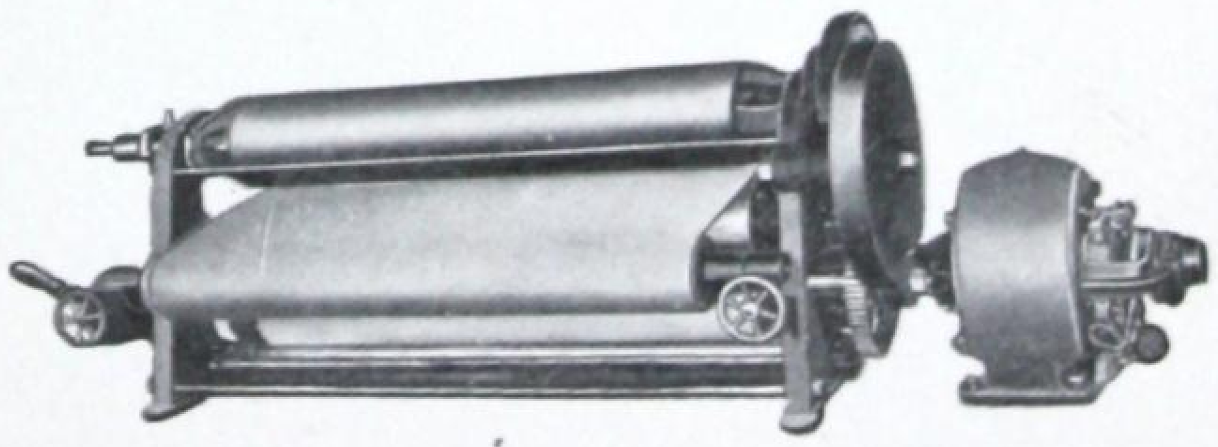
The drudgery inherent in house work on the farm may be to a very large extent done away with by means of the many labor-saving devices which the use of electric current renders available.

No one doubts the desirability of devices for heating and cooking without coal, gas or oil; without smoke, flame or soot—simply turned on and off by a switch as required. The extensive adoption of such devices depends simply on their reliability and economy.

The heating and cooking appliances designed and manufactured by the General Electric Company mark a new epoch in domestic science in that they employ electricity

Using a G-E Guaranteed Electric Iron

A Motor-Driven "1900" Washing Machine



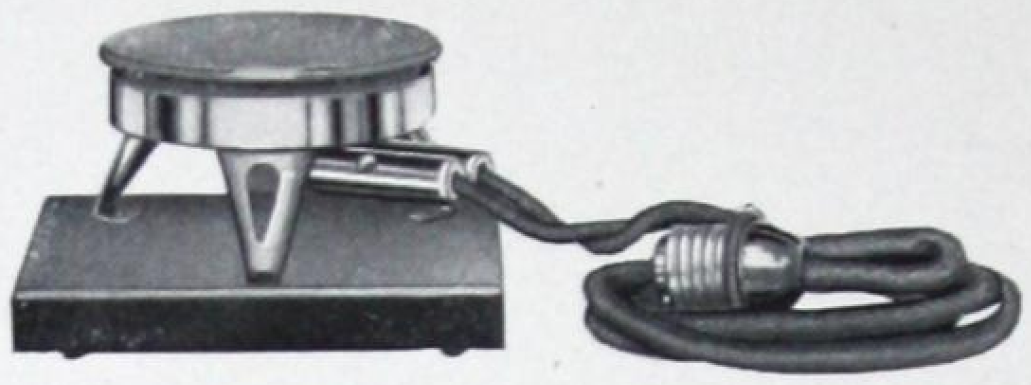
A Motor-Driven Mangle

to generate heat with absolute reliability and (when properly used) with excellent economy. They are *safe* even in the hands of the unskillful.

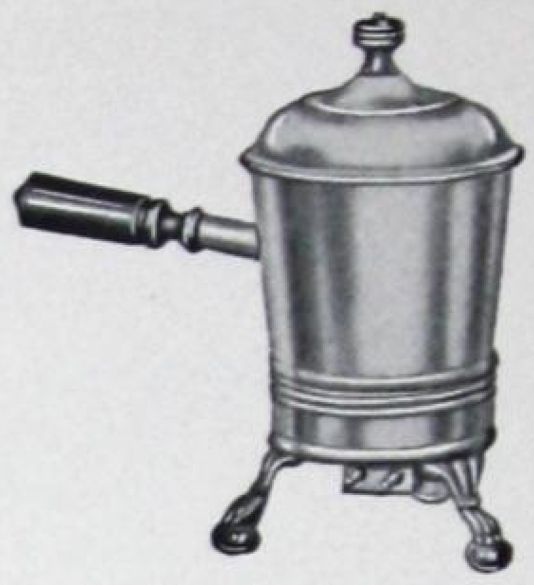
Each device has been developed to accomplish its particular purpose with the greatest facility, and many of them have already been classed as "indispensable" simply because of their convenience. They make *ideal housekeeping* possible for all.

These devices are designed to generate heat where it is wanted and to minimize useless radiation. Electric cooking and ironing will not appreciably increase the room temperature on the warmest summer day. Electricity produces heat without ash, soot, smell, flame, or gas of any kind.

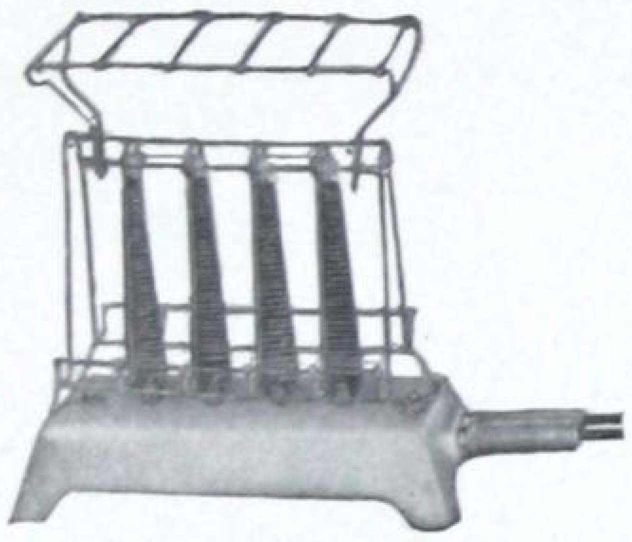
Chafing Dish



Disk Stove



Water Heater



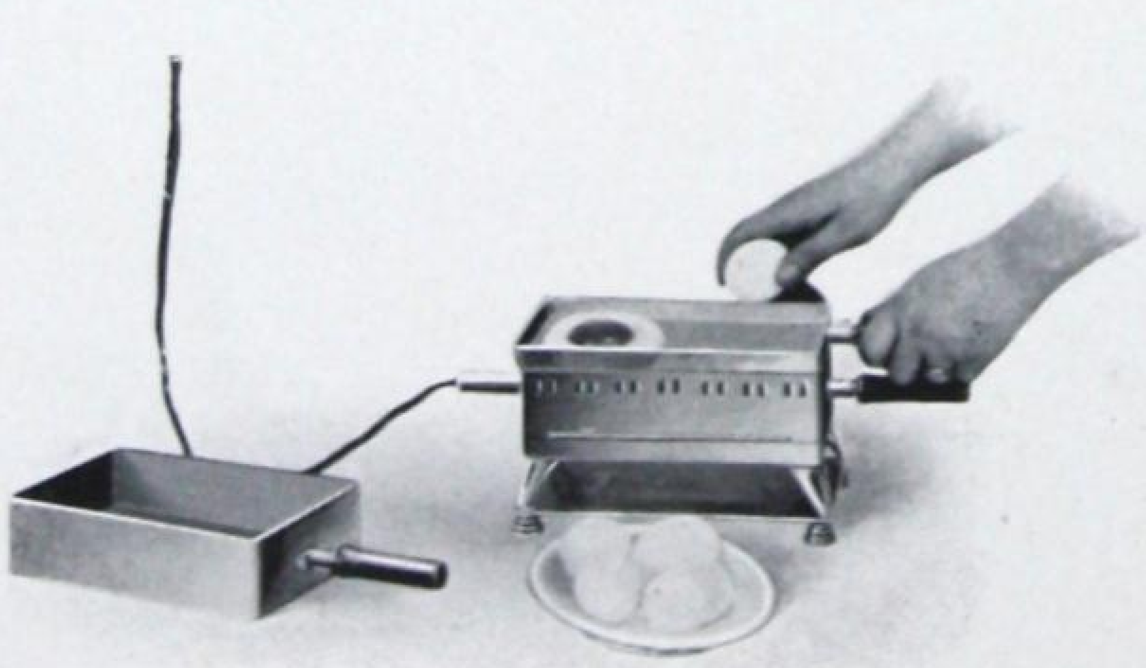
Radiant Toaster

Using a G-E Electric Range

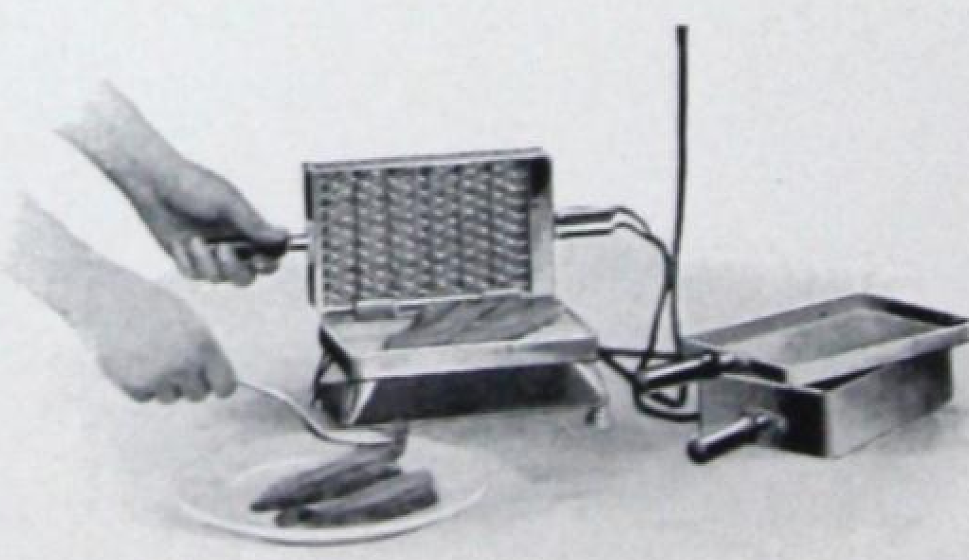
Coffee Percolator

Tea Kettle

Coffee Pot



With a G-E Radiant Electric Grill eggs may be fried at the table to suit one's taste



The G-E Radiant Electric Grill is just the thing for a hasty breakfast of grilled bacon and eggs

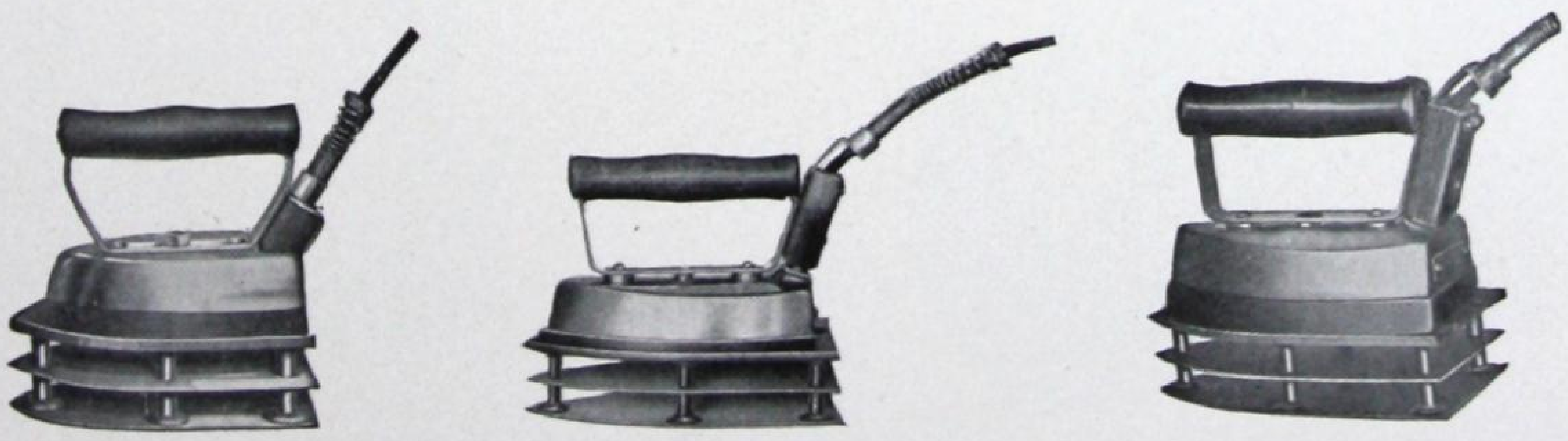
Nothing to do but guide the work

30,000 Stitches for One Cent

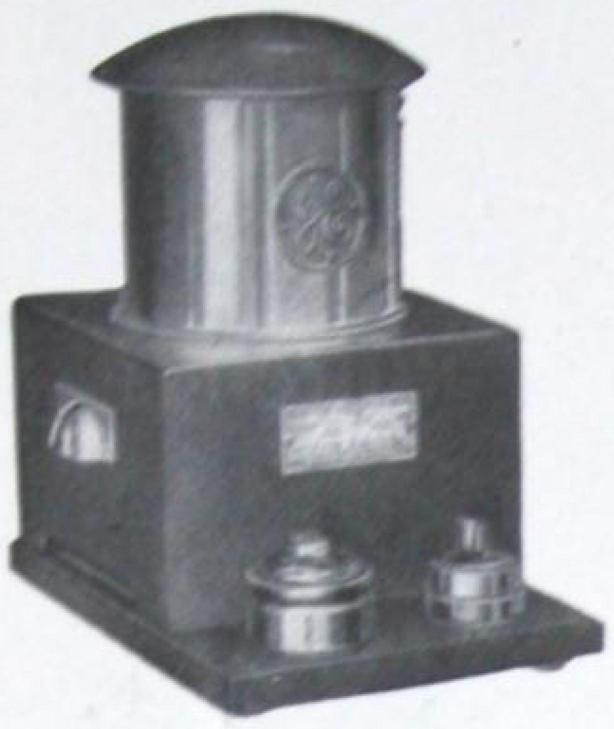
Using a G-E Sewing Machine Motor

Fifty Uses for Electricity in the Farm Home

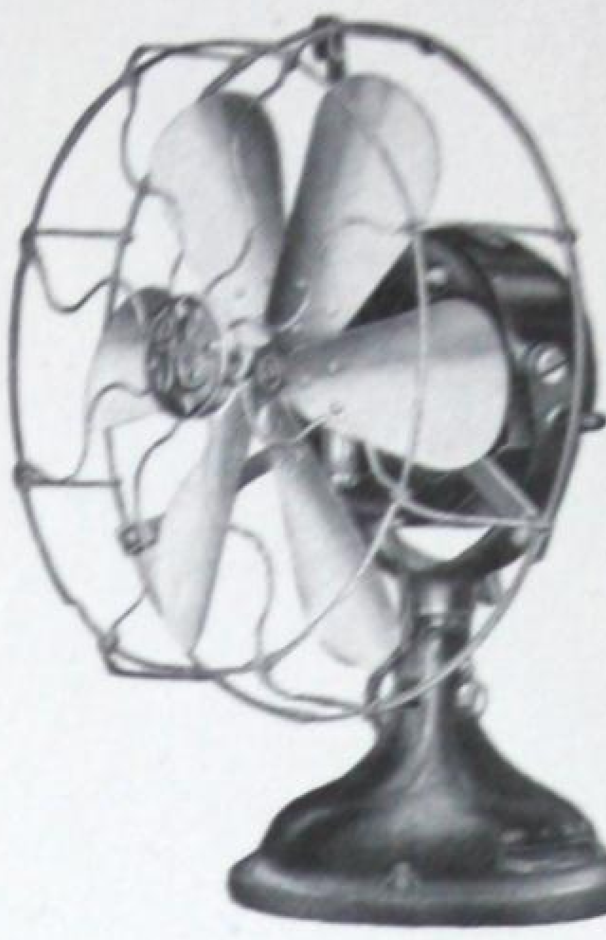
Lighting
Electric fan
Sewing machine
Electric iron
Washing machine
Wringer
Mangle
Pumps for water supply
Vacuum cleaner
Radiant toaster
Tea kettle
Coffee percolator
Chafing dish
Radiant grill
Baby milk warmer
Waffle iron
Hot plate
Frying pan
Griddle iron
Broiler
Soup kettle
Cereal cooker
Egg boiler
Egg beater
Corn popper
Water heater
Stove
Oven
Electric range
Fireless cooker
Meat grinder
Sausage stuffer
Coffee grinder
Bread mixer
Vegetable peeler
Plate warmer
Heating pad
Curling iron
Shaving mug
Cigar lighter
Sealing wax heater
Refrigeration
Ice crusher
Ice cream freezer
Buffer and grinder
Furnace blower
Foot warmer
Luminous radiator
Air heater
Ozonator



Three-, Six- and Eight-Pound Electric Flatirons



Household Ozonator



12-Inch Electric Fan

Luminous Radiator

The many electric heating and cooking devices manufactured by the General Electric Company are provided with practically indestructible heating units. They have proved so successful that there are today more than half a million of them in use.

A number of electrically operated auxiliary household devices are shown herewith and their value in reducing household work and as aids to comfort will be at once appreciated. The number of devices to which small electric motors may be applied is practically unlimited, but further information in regard to numerous devices which have already been developed may be secured by request for the publications on this subject. As a rule these small motors take very little current and a majority of them may therefore be operated from the ordinary lighting circuit.

One cent's worth of electricity at ten cents per kilowatt-hour will operate:

A 16 candle-power Mazda lamp for five hours

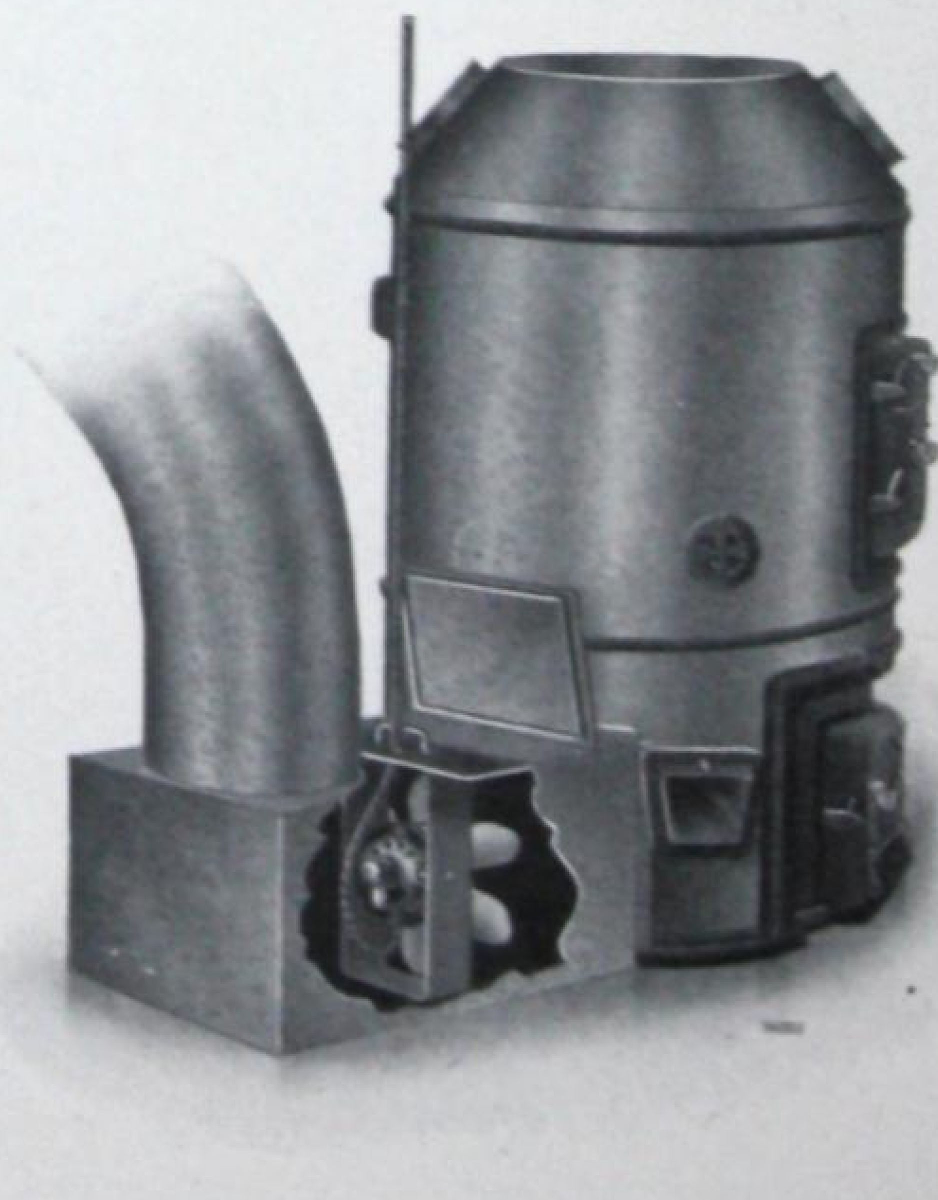
A six-pound flatiron fifteen minutes

An electric washer having a capacity of twelve sheets per washerful, long enough to wash twenty sheets

An electric vacuum cleaner long enough to clean four hundred and fifty square feet of carpet

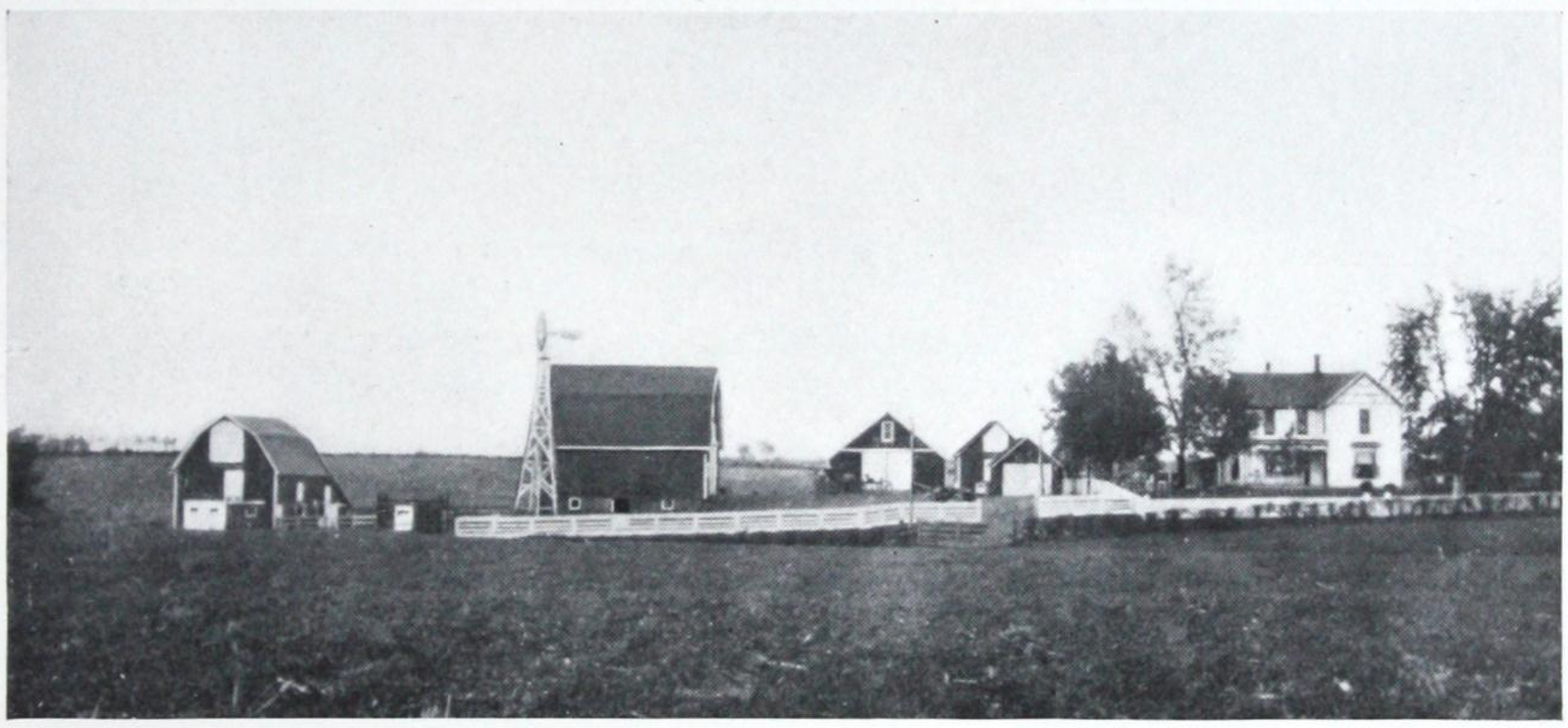
A pump long enough to raise one hundred gallons of water one hundred feet

Domestic Ice Cream Freezer



Electric Furnace Blower

A radiant toaster long enough to produce ten slices of toast
A sewing machine for two hours
A fan twelve inches in diameter for two hours
An electric percolator long enough to produce three cups of coffee
A heating pad from two to four hours
A domestic buffer and grinder for one and one-quarter hours
A chafing dish twelve minutes
A foot warmer for one-half hour
A water heater and bring to a boil one quart of water
An electric broiler six minutes
An electric griddle for eight minutes
A four-inch disk stove for twelve minutes
A radiant grill for ten minutes
An electric curling iron once a day for two weeks



Home of Mr. E. Shissler, Brimfield, Ill. Mr. Shissler Receives His Power from The Elmwood Electric Light Company's Lines. His Installation Consists of Eighty-two 16 c-p. Lamps, a Flatiron, a ½ H.P. Motor and a ¼ H P. Motor. He Drives Two Water Supply Pumps, Cream Separator and Washing Machine with These Motors. His Total Installation Cost Him About $200

Size of motors to use on different household machines:

Machine	H.P. of Motor		
	Min.	Max.	Size Most Commonly Used
Sewing machine	—	—	1/30
Buffer and grinder	1/30	1/30	Both
Vacuum cleaner	1/8	5	1/8 to 1/4
Ice cream freezer	1/8	1/4	1/8
Washing machine	1/8	2	1/8 to 1/2
Meat grinder	1/4	3/4	1/4
Water pump	1/4	1	1/2

Note.—It should be remembered in this connection that internal combustion engines are not made in fractional horse-power sizes.

Electric Drive

The electric motor is more desirable for farm use than gas engines and other forms of power, for the following reasons:

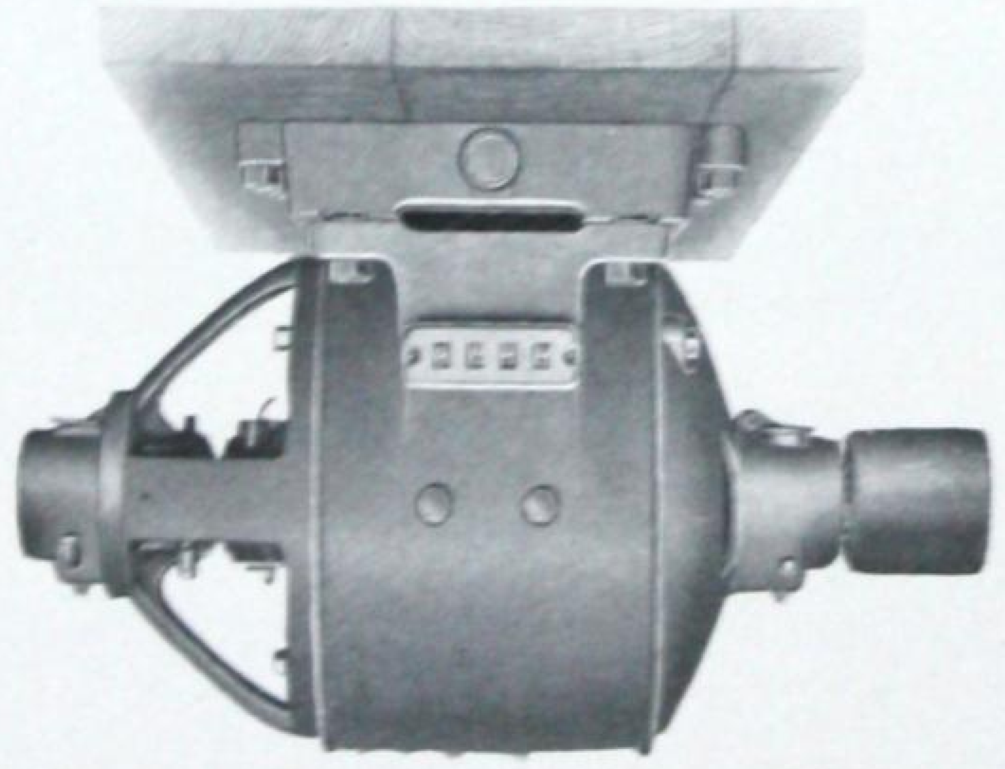
1. It is more reliable.
   A—Minimum of moving parts to get out of order.
   B—Only two bearings to watch and these need attention only about once every three months.
   C—No water to freeze.
   D—Starts just as easily in cold weather as in hot.

Direct Current Type

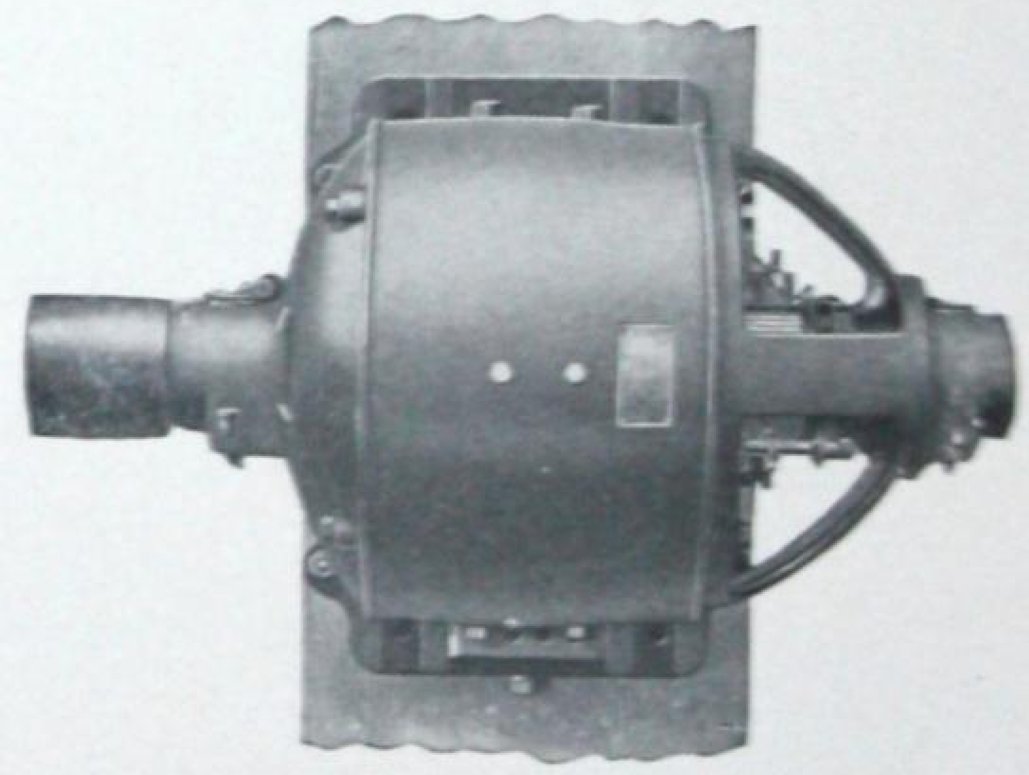
Three-Phase Alternating Current Type

Single-Phase Alternating Current Type

These Small Motors are Made up in Sizes Ranging from 1/30 H.P. to ¼ H.P. for Alternating Current and for Direct Current up to 2 H.P.



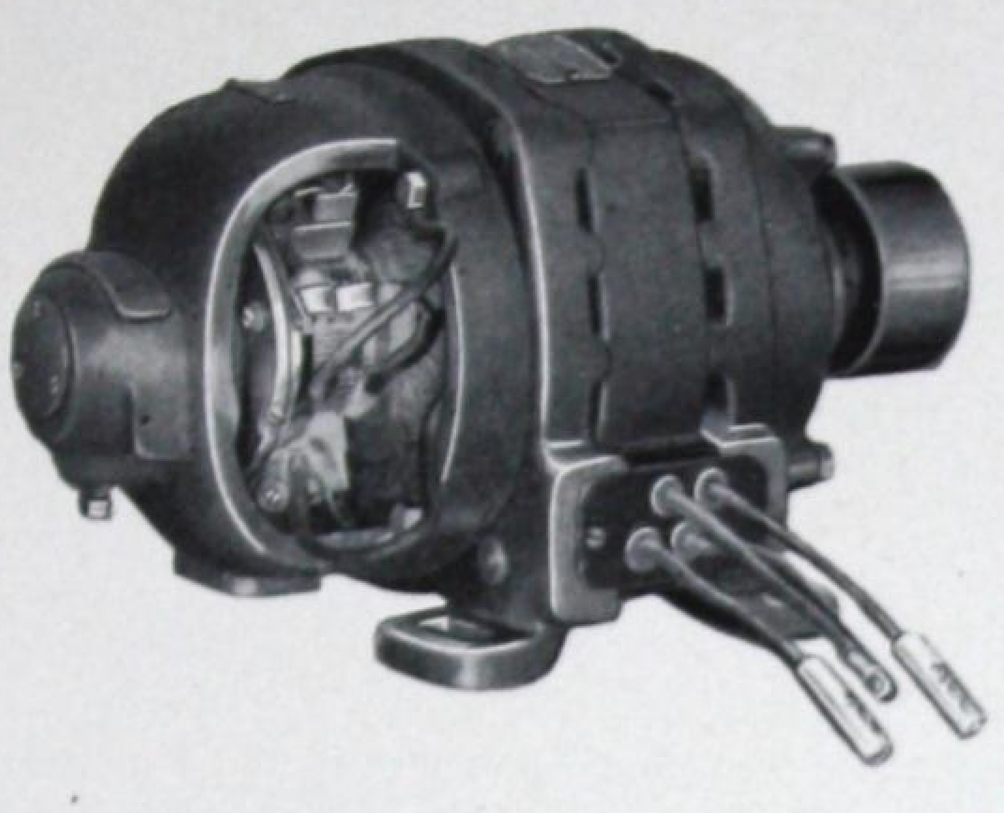
Direct Current Motor Installed on Ceiling Indicating the Inherent Adaptability of Motor Drive



Direct Current Motor Installed on Upright A Convenient Method Where Floor Space is Limited

The Motors Shown Above are Designed for Direct Current Service Only and Range in Size from 2 H.P. to 20 H.P.

2. Requires less attention.
   A—No parts to be adjusted to weather conditions.
   B—No fuel or water to haul.
3. Has greater overload capacity per rated horse-power.
4. Has a more constant speed than any gas engine.
5. Is easily controlled from a distance.
6. Can be attached to walls and ceilings.



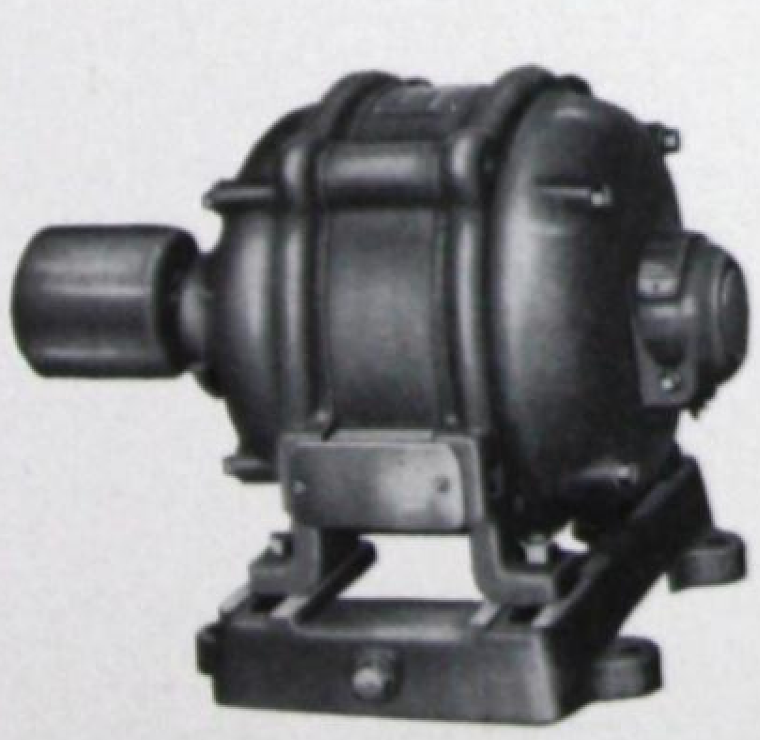
¼ H.P.

7½ H.P.

Motors of this Type are Designed for Operation on Single-Phase Alternating Current Circuits and Range in Size from ¼ H.P. to 15 H.P.

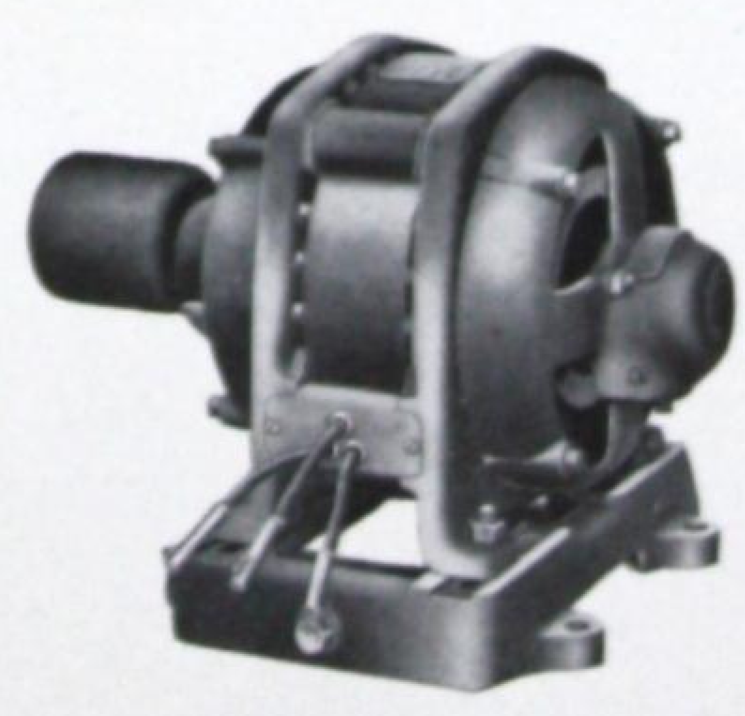
7. The electric motor has but 25 per cent of the weight and occupies only 15 per cent of the floor space required by the average gas engine of equal horse-power.
8. Reduces fire risk.
   A—Less danger from wiring than from boiler fire and gasolene.
   B—Enables the farmer to have an ever ready water supply for fire purposes.
9. Operates at higher speed, thereby reducing belt and transmission costs.
10. Can be made to operate automatically in the case of pumps, etc.
11. Is cheaper to install.
12. Costs less to operate.
13. Is "on the job" at all times—day or night.
14. Only electric motors are available in fractional horse-power sizes.
15. Power is the same regardless of the altitude.

The electric motor can be readily applied to all classes of farm and dairy machinery. The sizes of motors usually required are light in weight and can therefore be installed without special foundations. They may be mounted on the machine itself or on the floor, wall or ceiling, and drive by means of belts or gears; or, for some classes of machinery they may be direct connected to the driving shaft. The adoption of electric drive does



Totally Enclosed

Vertical Shaft Type

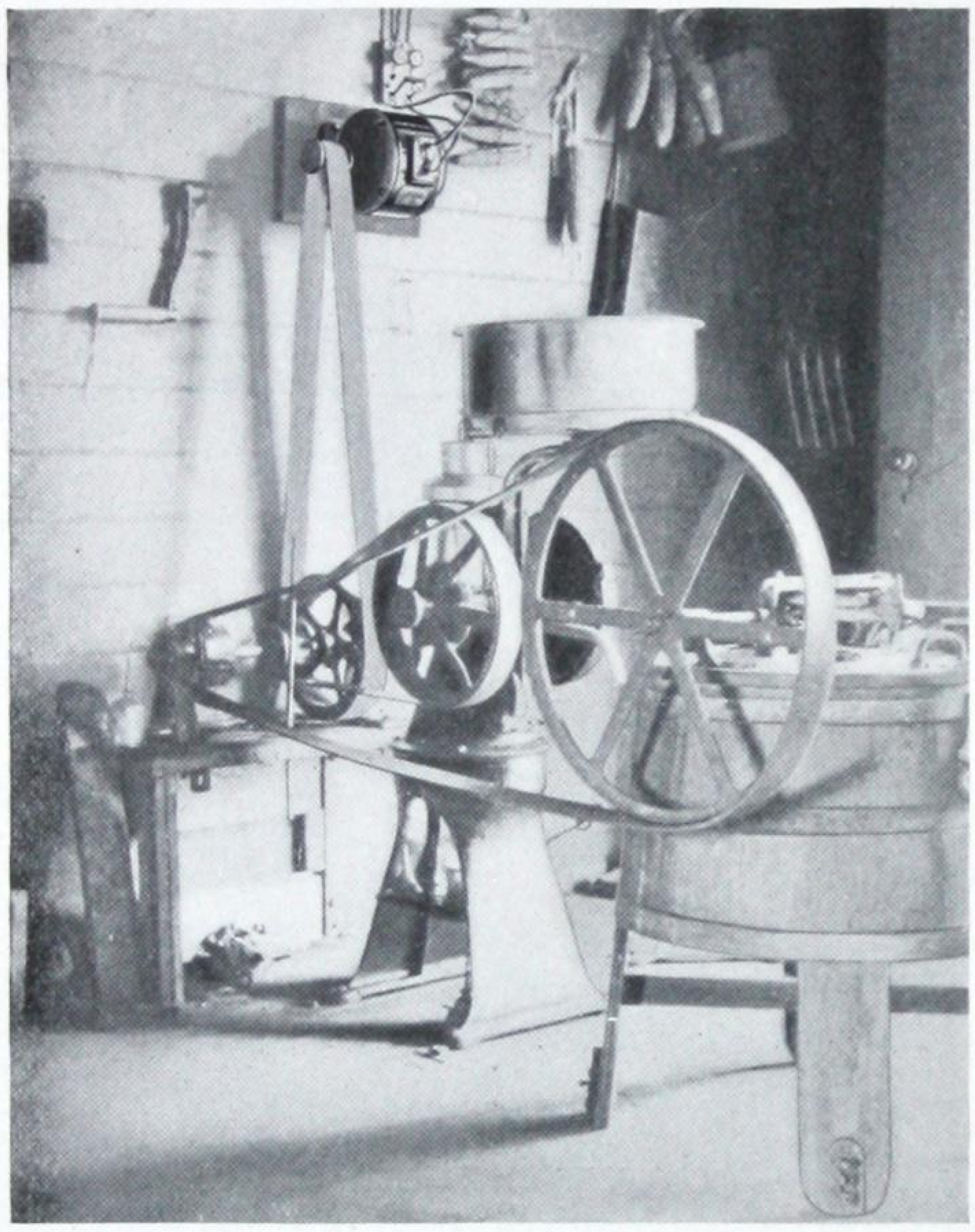


Standard Open Type

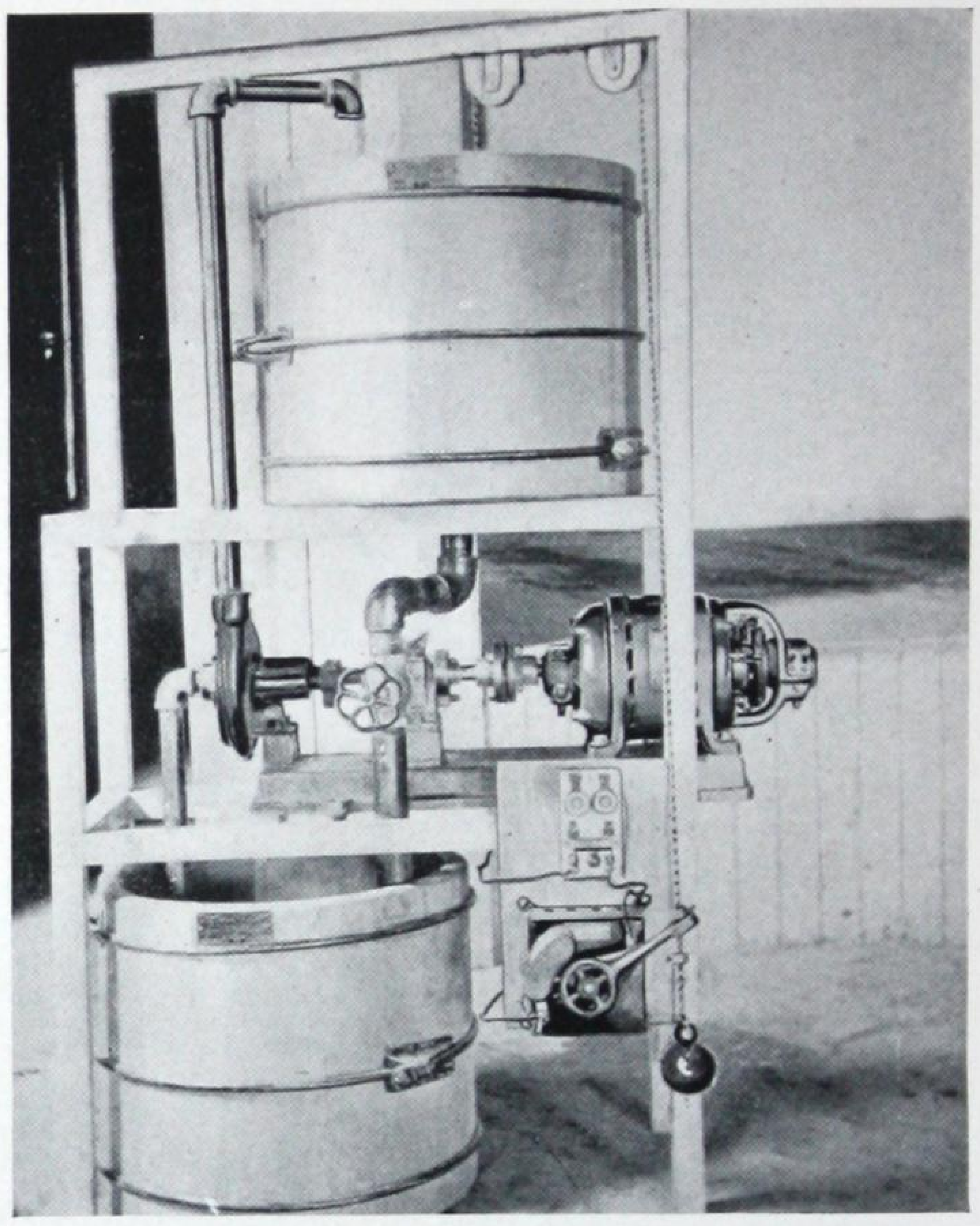
The Motors Shown Above are Designed for Operation on Polyphase Alternating Current Circuits and Range in size from ¼ H.P. to 15 H.P. and the G-E Company Can Supply Motors for Operation on Either Direct or Alternating Current Circuits in any Size up to 6000 H.P.

not involve any radical change in existing machinery, and even the hand operated machines may be driven by small motors by simply substituting a pulley for the hand-wheel or crank.

A complete line of motors for this service is manufactured by the General Electric Company and all sizes are provided with either starting switches or controllers which can be safely operated by anyone. The motors themselves are constructed of few parts, are mechanically strong, and, except for an occasional cleaning and oiling, will operate continuously without attention.



Cream Separator and Washing Machine Operated by ¼ H.P. Motor on the C. M. Bliss Farm, Yates City, Ill.



Automatically Controlled Pumping Set with Centrifugal Pump Direct Driven by Alternating Current Motor

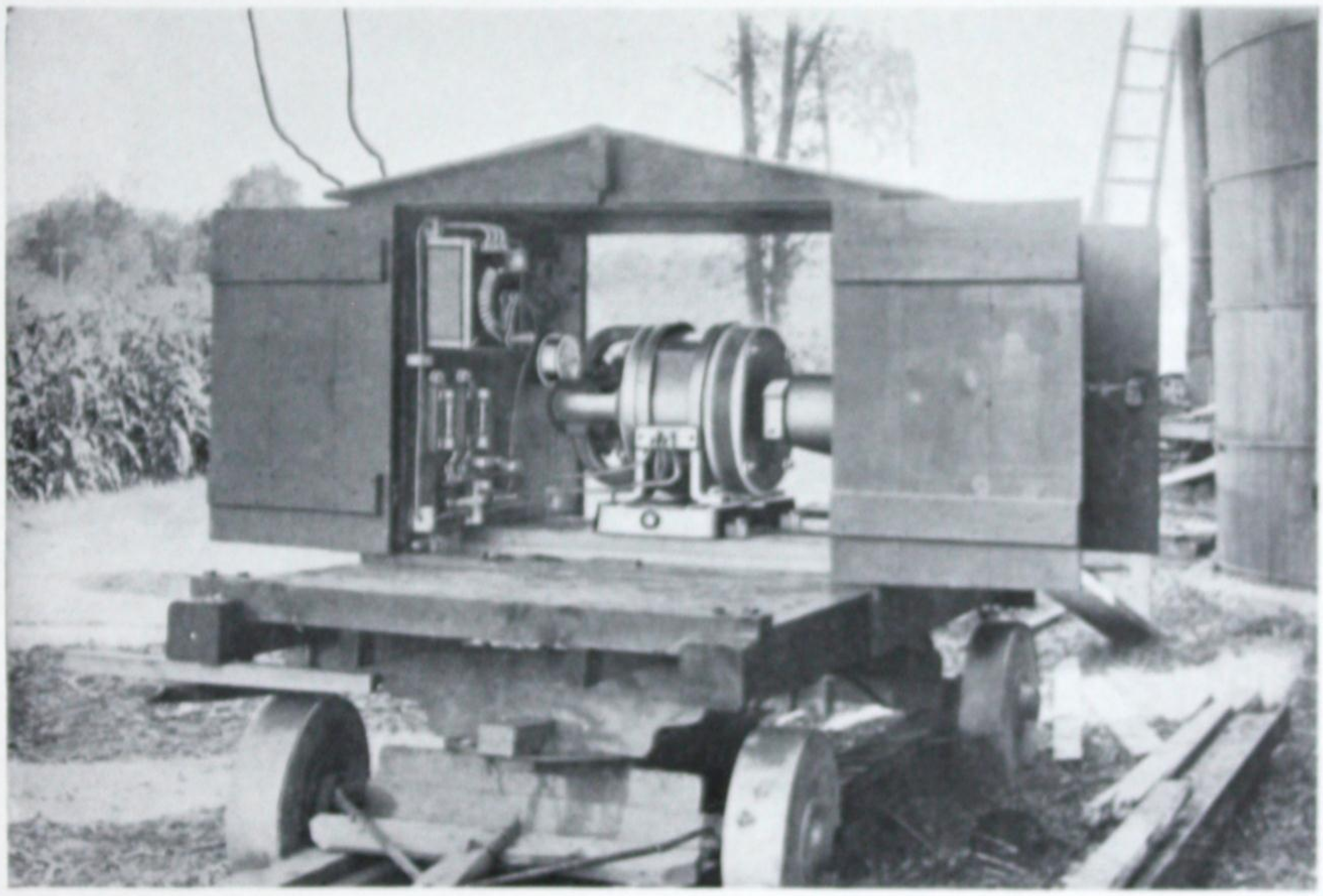
If alternating current induction motors are used, they may be safely installed inside the farm buildings, and as they have no commutator or other moving electrical contact, there is an entire absence of danger from sparking. This type can therefore be utilized without risk of fire in buildings where there is inflammable dust such as is found in grist mills, grain storage lofts and carpenter shops. Where direct current only is available, the motors used for driving this class of machinery should be installed in a separate building, or else should be provided with protective covers.

The greatest economy in the consumption of electric current can generally be obtained by providing each machine with an individual motor, as in this case, if current is received from a central station or trolley company's lines, the cost of operating the machine is only entailed during the time it is actually running. The use of individual motors will usually permit each machine to be equipped with the smallest sized motor which can efficiently operate it, so that if it is necessary for the farm to install its own

generating plant a smaller generator will be required than if larger motors were used to drive several machines in a group, although group drive can in many cases be profitably adopted.

Much of the farm machinery is in operation for only short periods each day, so that in case electricity cannot be purchased for farm work, a relatively small generator will supply ample current for a set of motors whose aggregate horse-power is considerably greater than the capacity of the generator, as the generator need only supply sufficient current for the operation of the largest number of motors that would be in service at one time.

In order to reduce the first cost of the motor equipment it has been the practice in some instances to provide a portable motor, which can be moved from building to building and belt connected to the various machines, or transported to the field for the operation of threshers, loaders and other machinery. In this latter case it is of course necessary to run wires to the point at which the motor will operate; these wires can be carried on a reel, unwound as the motor is taken into the field, and rewound upon its return.

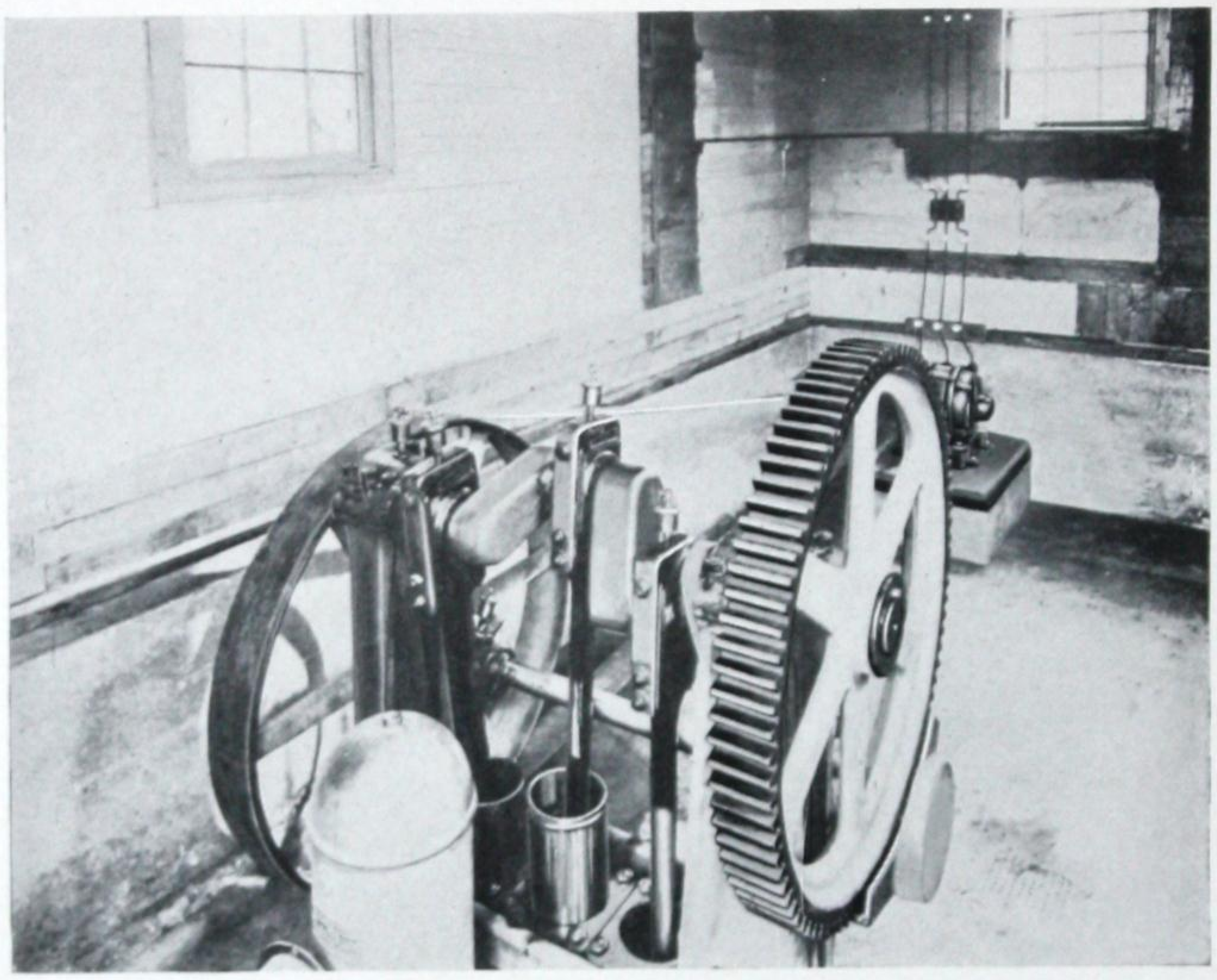


Arrangement of a Portable Motor Outfit for Farm Service

The General Electric Company does not make or sell farm machinery but can supply every device necessary for a complete electrical outfit, including gasolene, steam engine and steam turbine-driven generators, all types and capacities of both alternating and direct current motors and controllers, with a full line of wiring devices, instruments and of auxiliary electrical apparatus in general.

Electric Drive for Dairy Apparatus

The characteristics of the electric motor render it especially valuable for the operation of the dairy equipment. The requirements of modern sanitation have brought the vacuum process of milking into common use and in numerous installations electric motors are utilized to drive the vacuum pump. Typical equipments of this kind are shown on page 19. If we compare this method of drive with that of using gasolene engines for this purpose, it is obvious that the electric equipment is more compact and that the motor and the pump can be readily mounted on a common base, making a self-contained unit which can, if necessary, be installed in the cow barn, as there is an entire absence of fire risk with this equipment.



Typical Motor-Driven Pumping Equipment on a New York Dairy Farm. This Pump Forces the Water Into a Large Underground Storage Tank and from There it is Distributed to the Dairy, House and Barn. Note the Cleanliness, Simplicity and Compactness of this Equipment

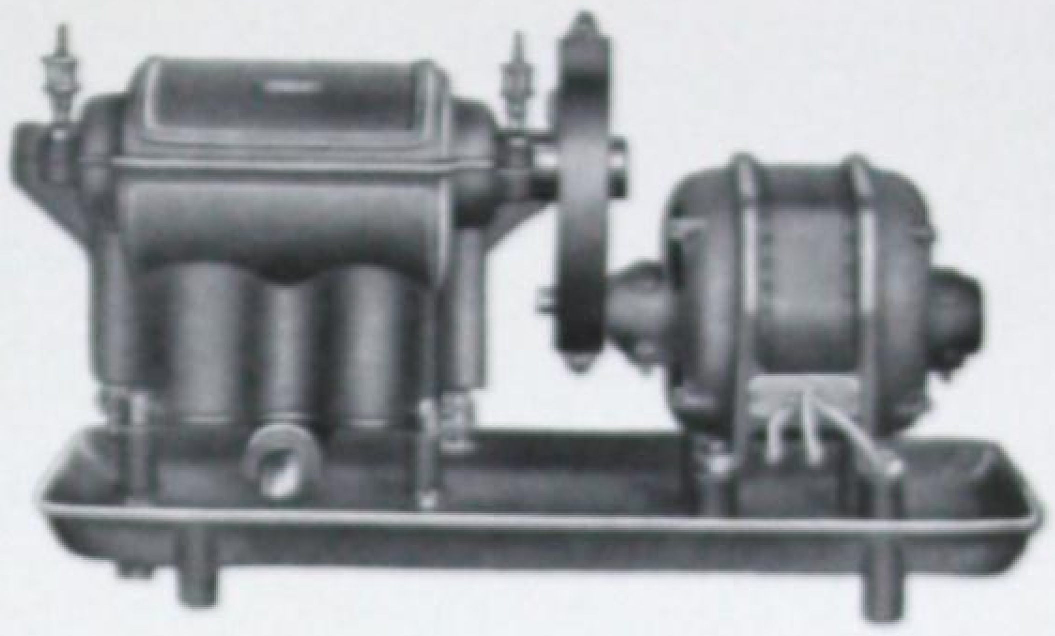
The power used for these vacuum pumps ranges from one to three horse power, depending upon the size of the equipment.

Motors are well adapted for the operation of cream separators, and as they take little power, they may in most instances be operated direct from an incandescent lighting circuit. The motors can be mounted on the wall, floor or ceiling near the separator, and belt connected to it; or, they can preferably be mounted close to the driving wheel.

The electric motor can be adapted with equal success to either the barrel or factory type of churn, and drive either through gears or by belt connection to the churn pulley.

Where it is necessary to pump the milk into the churn, compact centrifugal or reciprocating pumps can be used. In the case of the centrifugal pump the motor can be direct connected to the pump shaft and a motor selected for this purpose having a speed which will insure the maximum working efficiency of the pump.

Pasteurizers and testers are frequently operated by motors, the vertical shaft type being especially adapted for this work; bottle and can washers can also be readily equipped with motor drive.



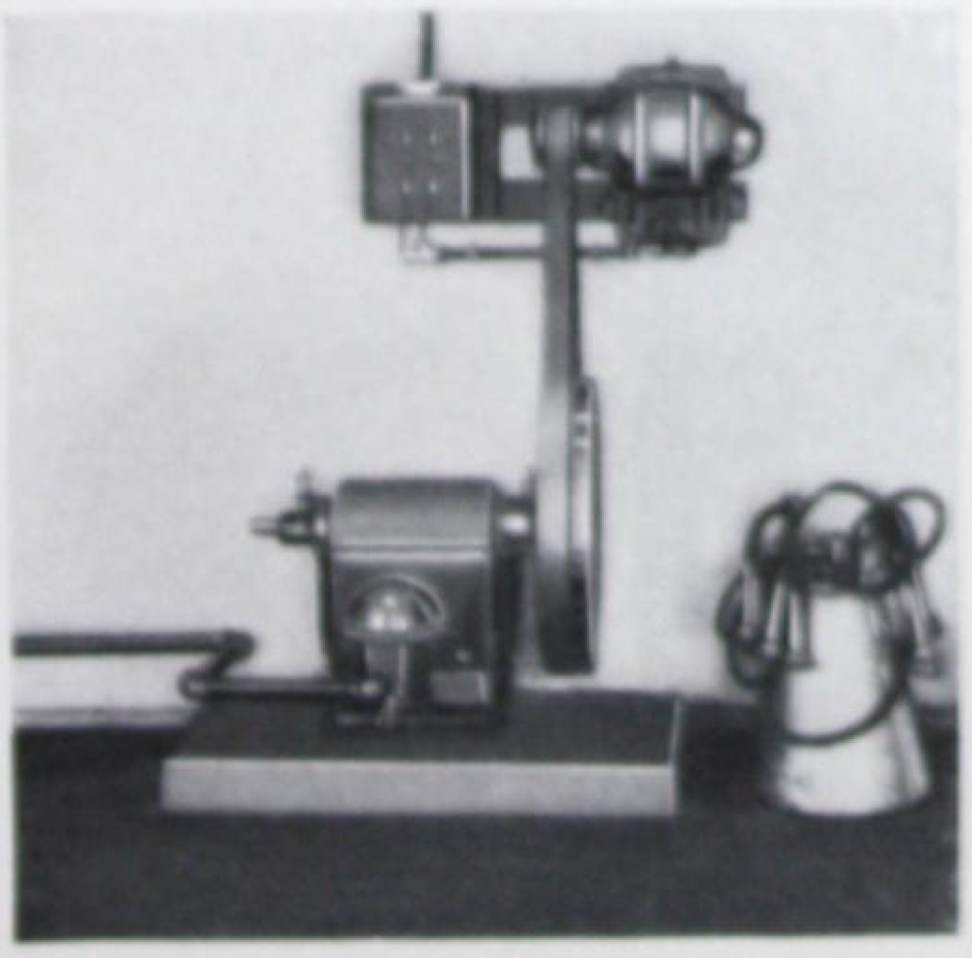
1½ H.P. Motor Direct Geared to a No. 4 "Burrell" Vacuum Pump

In some instances, the dairy machinery when compactly arranged can be economically driven in a group by a single motor and shafting, but greatest economy in current consumption is obtained when each unit is provided with a separate motor.

The absolute cleanliness of electric motor drive renders possible the operation of dairy machinery under perfectly sanitary conditions.

A cent's worth of electricity at ten cents per kilowatt-hour
Will separate seven hundred pounds of milk
Will churn ten pounds of butter
Will milk five cows if the machine is capable of milking sixteen cows at a time.

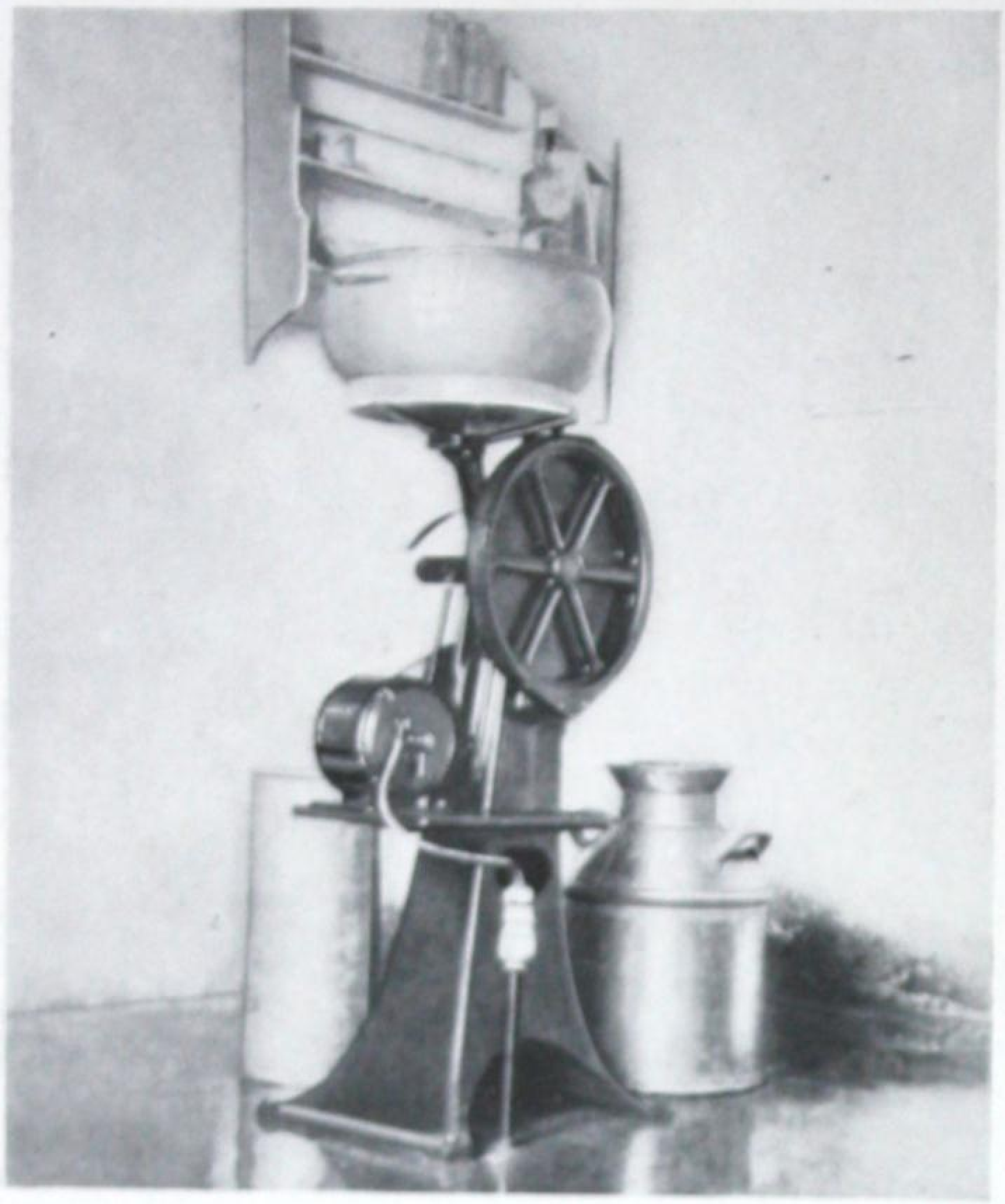
Milking with an Electrically-Operated Vacuum Milking Outfit. Figures Given by Mr. John Bowditch of Framingham, Mass., Show that His 3 H.P. Electric Milking Machine Has Paid for Itself in Eleven Months by Reducing the Necessary Labor from Twelve to Five Men



Motor-Driven Vacuum Milking Outfit with Motor Mounted on Wall and Belt Connected to Vacuum Pump

Twenty Uses for Electricity in the Dairy

- Cream separators
- Water pumps
- Churns
- Butter workers
- Butter cutting and printing machines
- Lighting
- Refrigeration
- Milking machines
- Milk cooling circulating pumps
- Bottle washers
- Cream testers
- Milk clarifiers
- Cream ripeners
- Milk mixers
- Butter tampers
- Milk shakers
- Curd grinders
- Casein grinders
- Pasteurizers
- Ice breakers

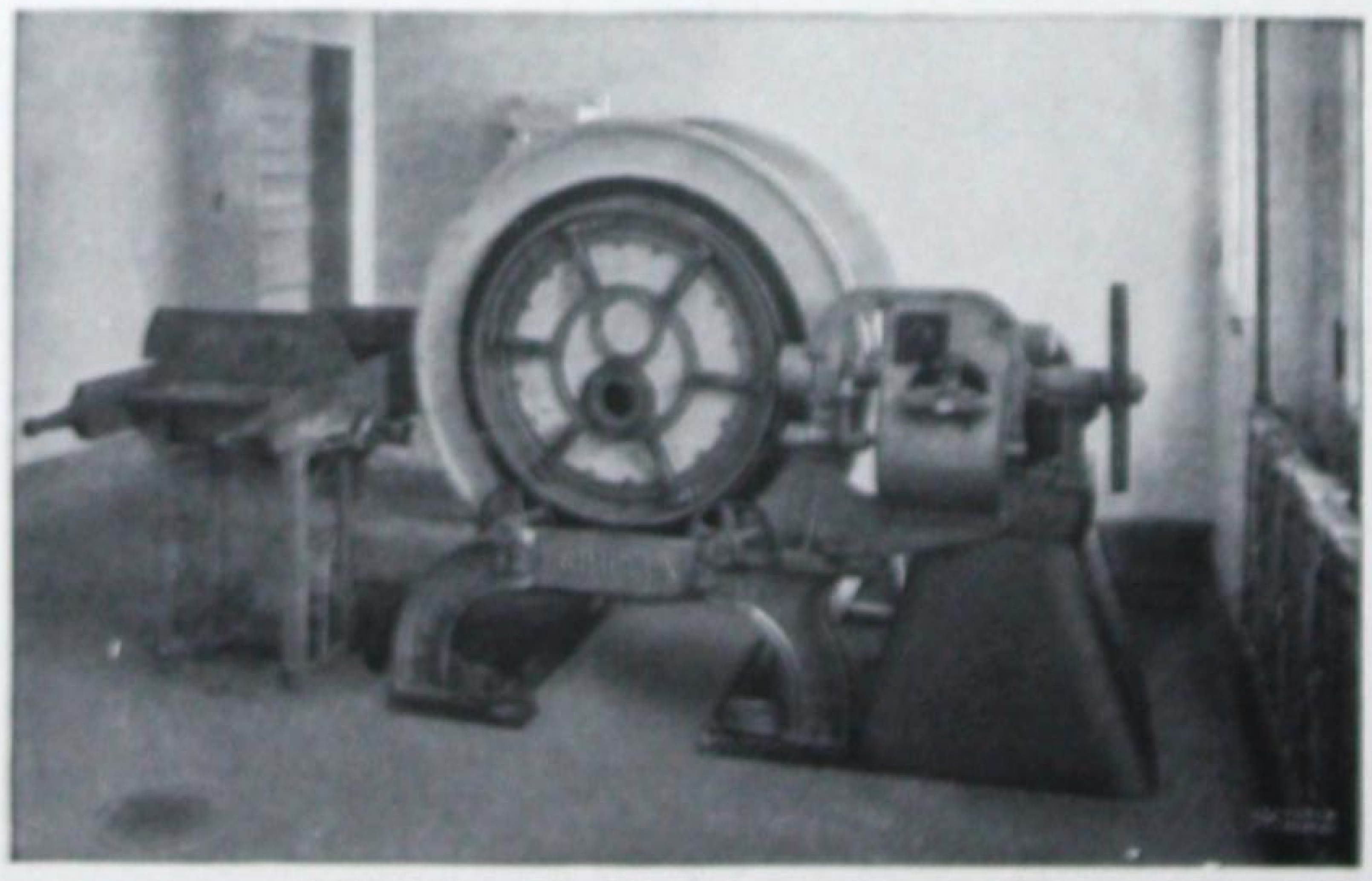


Motor-Driven Cream Separator on Farm of Mr. C. D. Ettinger, Midlothian, Ill.

Motor-Driven Cream Separator on Farm of Mr. J. M. Corey, Yates City, Ill.

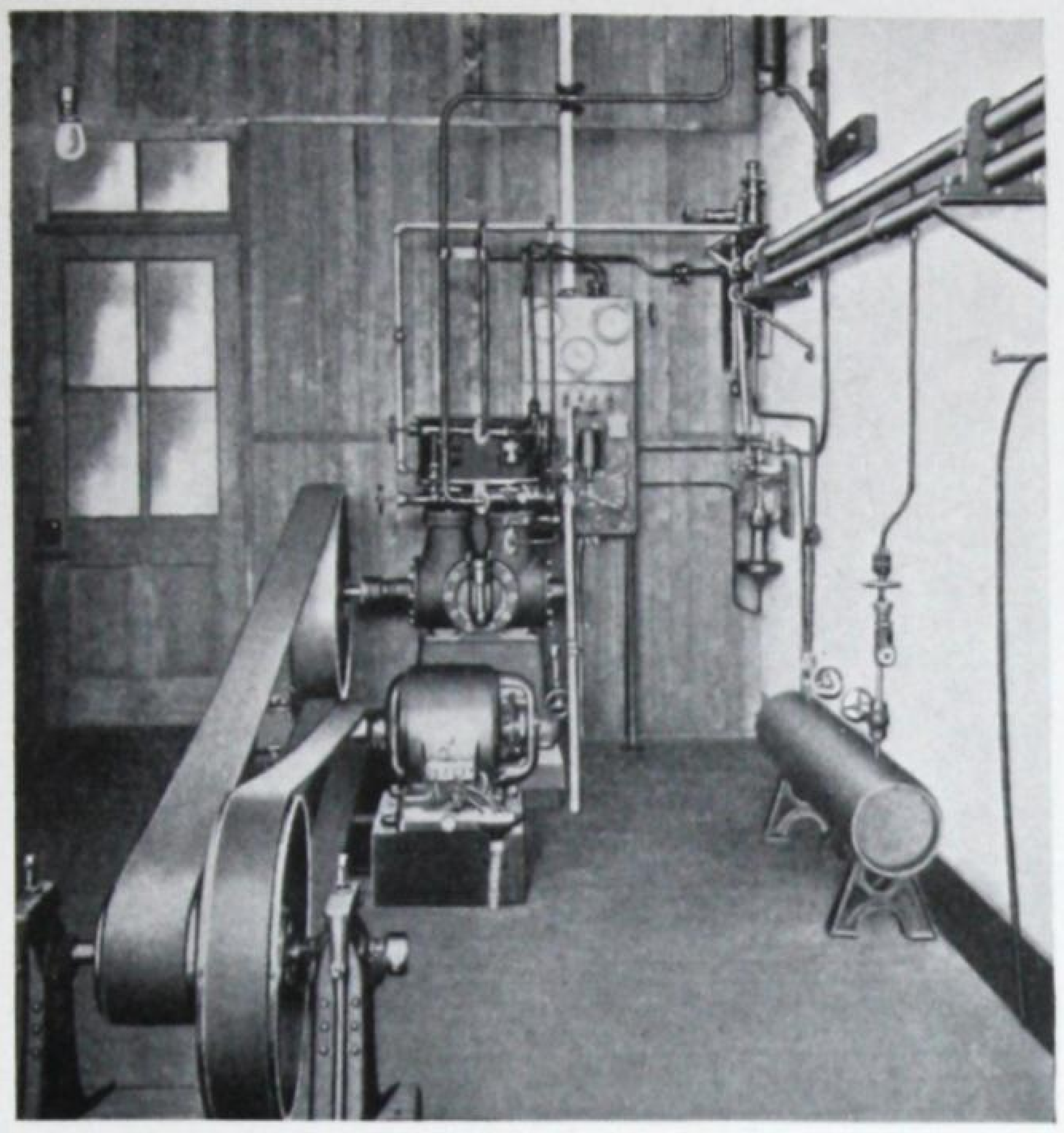
Size of motors to use on different dairy machines:

Machine	H.P. OF MOTOR		
	Min.	Max.	Size Most Commonly Used on Average Farm
Water pump	1/2	5	3
Cream separator	1/10	1/4	1/8
Churn	1/8	3	1/4
Milking machine (vacuum system)	1	3	3
Refrigeration	1/2	10	5

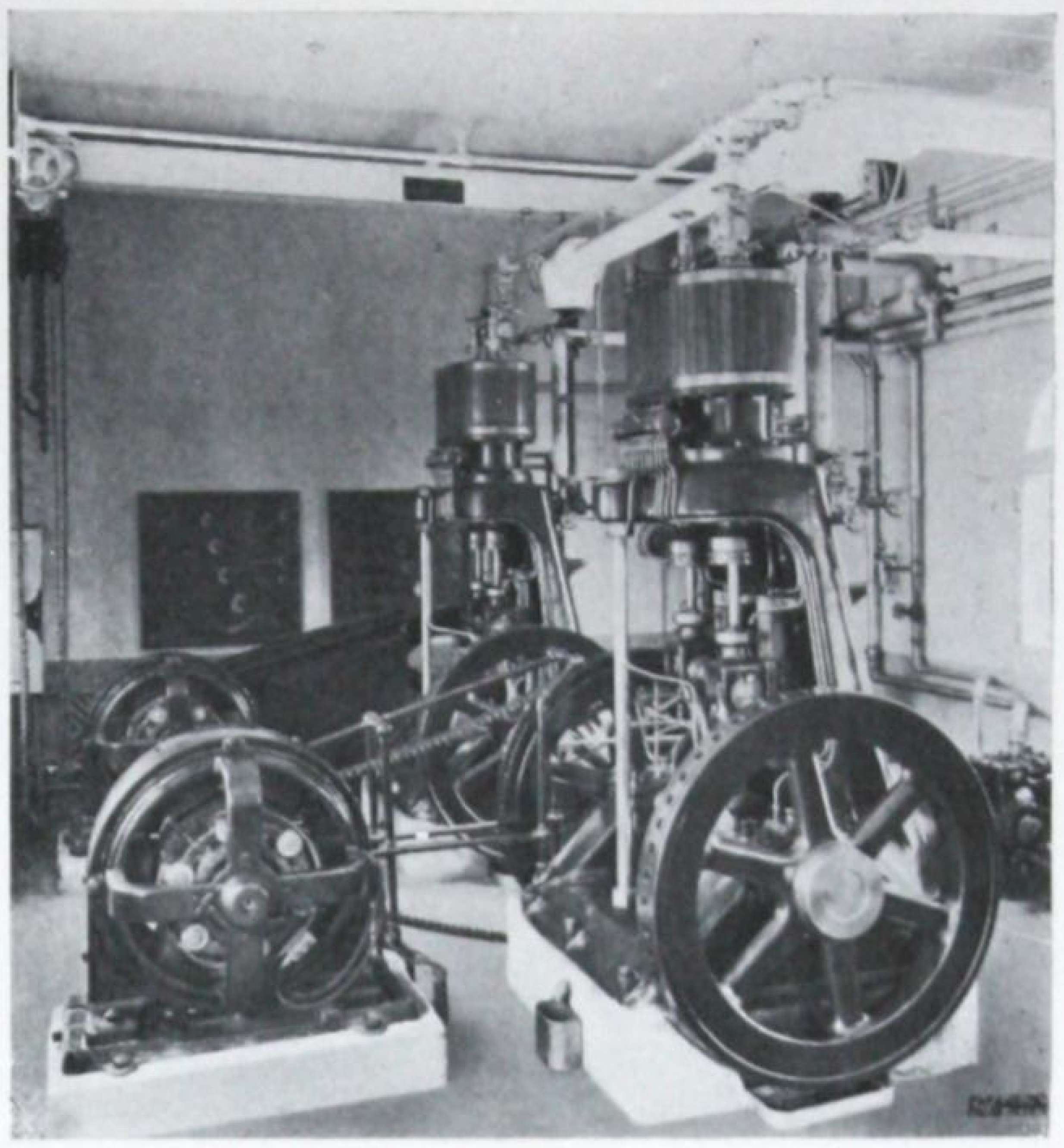


100 Gal. Butter Churn Driven by 3 H.P. Motor, Direct Geared. Hearts' Delight Farm, Chazy, N. Y.

Accurate Tests on this Churn Show that it Costs Less than 1/10 of a Cent to Churn, Wash and Work a Pound of Butter Even When Using Electricity Costing 10c. per Kilowatt-Hour



Motor Driving "Automatic" Refrigerating Outfit
Courtesy of the Automatic Refrigerating Co.

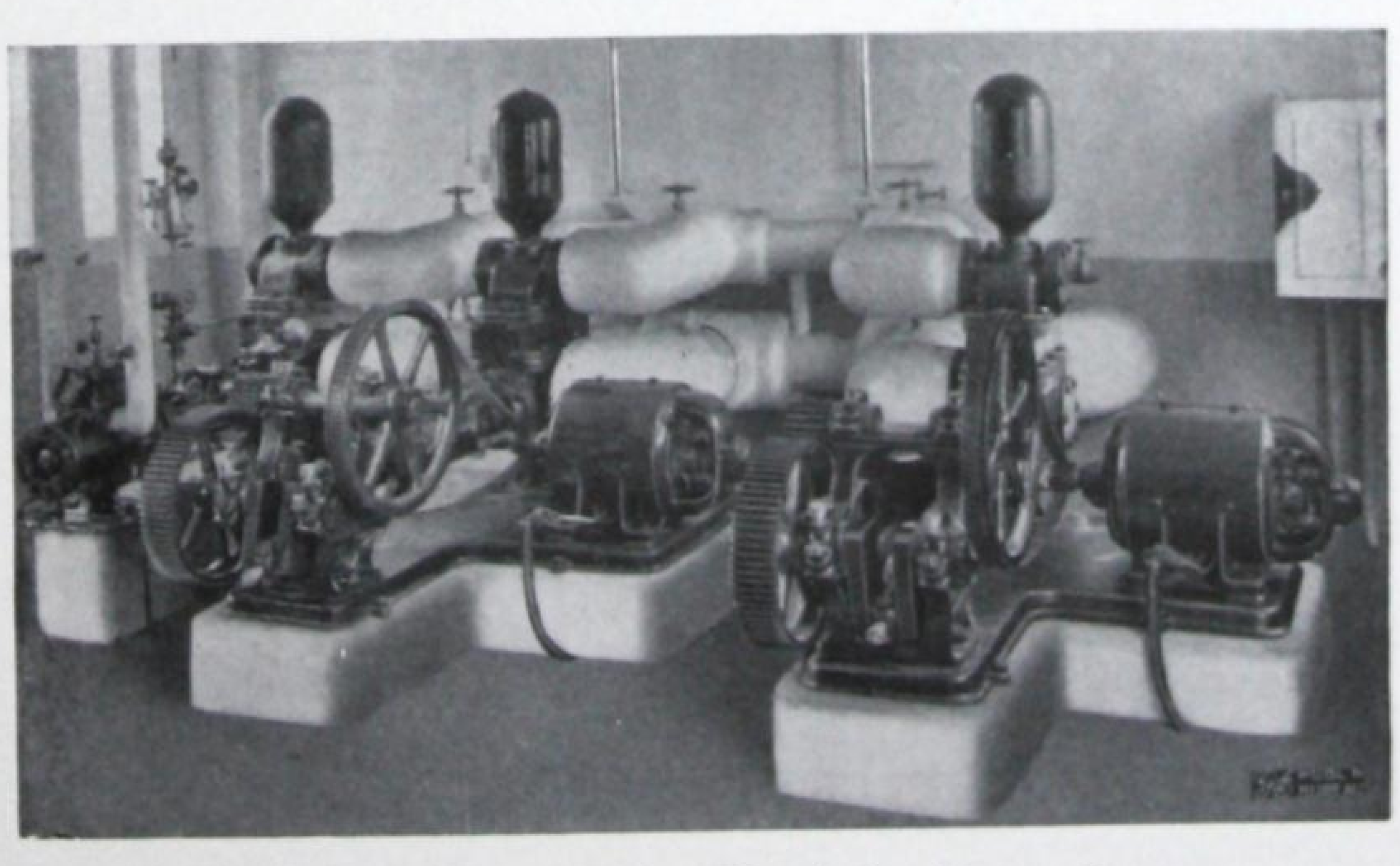


Motors Driving Ammonia Pumps Through Chain Belts in Farm Ice-Making Plant

On a farm supplied with electric current, motors afford an ideal method of operating refrigerating plants. Cold storage, by means of natural ice, has three inherent defects: the presence of considerable moisture or dampness, the impossibility of regulating and controlling the temperature, and a constant reduction of the available energy. In addition to this, there is the labor and time involved in cutting and storing the ice, and the inherent danger of impurities which do not exist in ice artificially made with pure spring or well water.

The first cost of the building for storing the ice is also eliminated, and the space heretofore occupied by the ice in the cooling rooms or refrigerator becomes available as storage room for the farm produce.

An electrically-driven refrigerating plant can readily be made automatic in operation by means of a thermostat placed in the chamber where refrigeration is required, which automatically starts and stops the motor-driven pumps at predetermined temperatures.



Motor-Driven Brine Circulation Pumps in Farm Ice-Making Plant

Cutting Green Rye for Ensilage by Electric Power at the Farm of E. F. Belches, Framingham, Mass.

Electric Motor Driving a No. 19 "Ohio" Self-Feed Blower Ensilage Cutter

Electric Motor Drive for Barn and Field Machinery

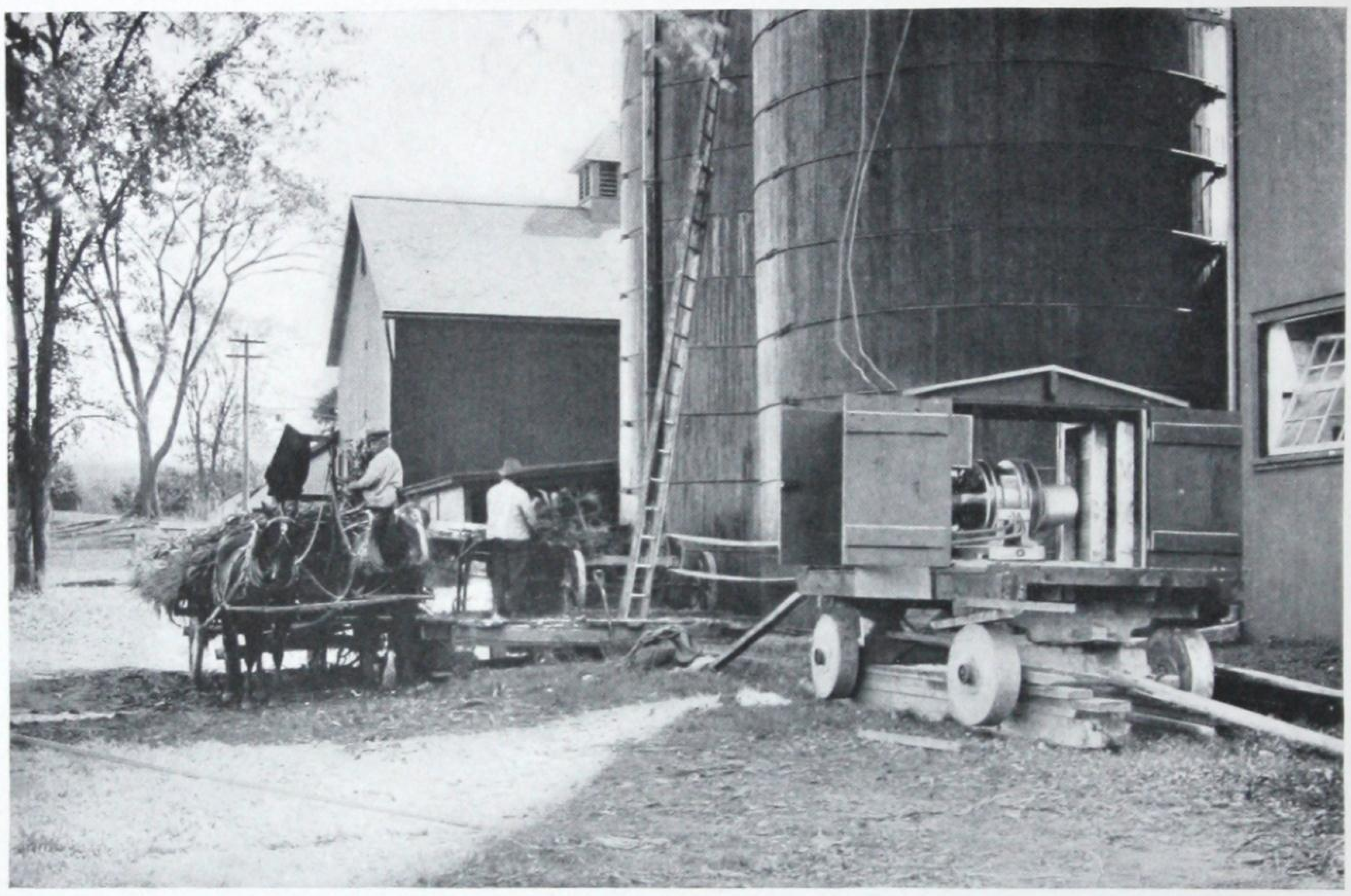
An important advantage in the operation of barn and field machinery by means of electric motors is the fact that the power is at all times instantly available, and the operation of the machines can be safely and effectively controlled at all times. In operating feed grinders, oat crushers, corn crackers, alfalfa mills, etc., the work requires the services of only one man, and the feed can be economically ground for use as it is needed; it is, therefore, unnecessary to prepare and store it in quantity.

The illustration herewith shows a feed grinder installed on the 240 acre farm of Mr. Samuel Leman, near Eureka, Ill. Feed grinding is only one of the many operations carried on electrically on this farm, there being also a wood saw, cream separator, washing machine and tool grinder, all of which are motor-driven. The house and barn are lighted by means of seventy-eight 16 c-p. incandescent lamps. Both the feed grinder and wood saw are driven by a 5 h.p. motor, while the other machines referred to are group driven by means of a line shaft belted to a ¼ h.p. motor. These two motors replaced a gas engine, and the bill for electric current consumed for all the lighting and power, averages about $3.70 per month.

Feed Grinder and a Wood Saw Operated by a 5 H.P. Motor

In driving ensilage cutters, threshers, huskers, shredders, and clover hullers, by means of motors, there is obtained the advantage of a more uniform operating speed than can be secured with either steam or gas engine drive. During the intervals when the machines are not operating (such as the time spent in waiting for loads) there is no cost for power as the charge for electric energy is involved only during the time the machine is actually running.

For operation of ensilage cutters, the farmer who has electric service can perform this work at any convenient time, which is not always the case when a power plant for this work has to be rented. Machines can safely be set in the barn or near combustible material, and electrically operated without involving risk of fire, and with all but the ensilage cutter the motor can usually be mounted upon the machine itself. The operation of the machines by means of motors does not require the services of an engineer or expert attendant, as the motor can be instantly started or stopped by simply throwing a switch. The element of personal danger in operating machinery of this class is minimized by the simple and strong construction of the modern electric motor, coupled with the fact that it is under the instant control of the man who is feeding the machine.



The RI motor on the Farm. An RI 15 H.P. Motor Driving Ensilage Cutter on Flintstone Farm, Dalton, Mass., Owned by Fred G. Crane

A motor-driven ensilage cutter which is a good example of the economy obtained by electric drive for this class of work is located on the farm of Mr. John Bowditch at Framingham Center, Mass. The silo is 32 feet high, has a capacity of 200 tons, and is filled by an Ohio No. 14 ensilage cutter. Last year this silo was filled by means of a hired steam engine, which cost $45 for rental, fuel and services of an engineer. This year the same work was done by a 15 h.p. electric motor which cut about 13 tons per hour, with a total cost of $16 for electric current.

The threshing machine shown on page 25 is used by the University of Illinois Experiment Station to thresh the grain from the plots on the experimental farm.

The machine has a 28 in. cylinder, a 42 in. separator and is driven by a 15 h.p. electric motor. The grain and straw from each plot is weighed and accurate records kept of the results. During the summer of 1912 careful tests were made by the General Electric Company to determine the amount of power required to thresh a bushel of grain. It was

found that this varied over a wide range, but that the amount of power required per ton of grain and straw was fairly constant.

The following table shows the results of these tests:

Kind of Grain	No. of Tests Made	Yield per Acre		Kw-hr. to Thresh One Ton	Kw-hr. to Thresh One Bu.	Cost of Power at 5c. per Kw-hr.	
		Tons of Grain and Straw	Bu. of Grain			Per Ton	Per Bu.
Oats	31	1.99	73.6	2.62	0.070	0.13	$0.0035
Barley	5	2.27	49.9	2.36	0.108	0.128	0.005
Wheat	10	1.97	27.9	2.27	0.160	0.113	0.008

Motor-Driven Threshing Machine on the Experimental Farm of the University of Illinois

Thirty Applications of Electric Drive for Barn and Field Machinery

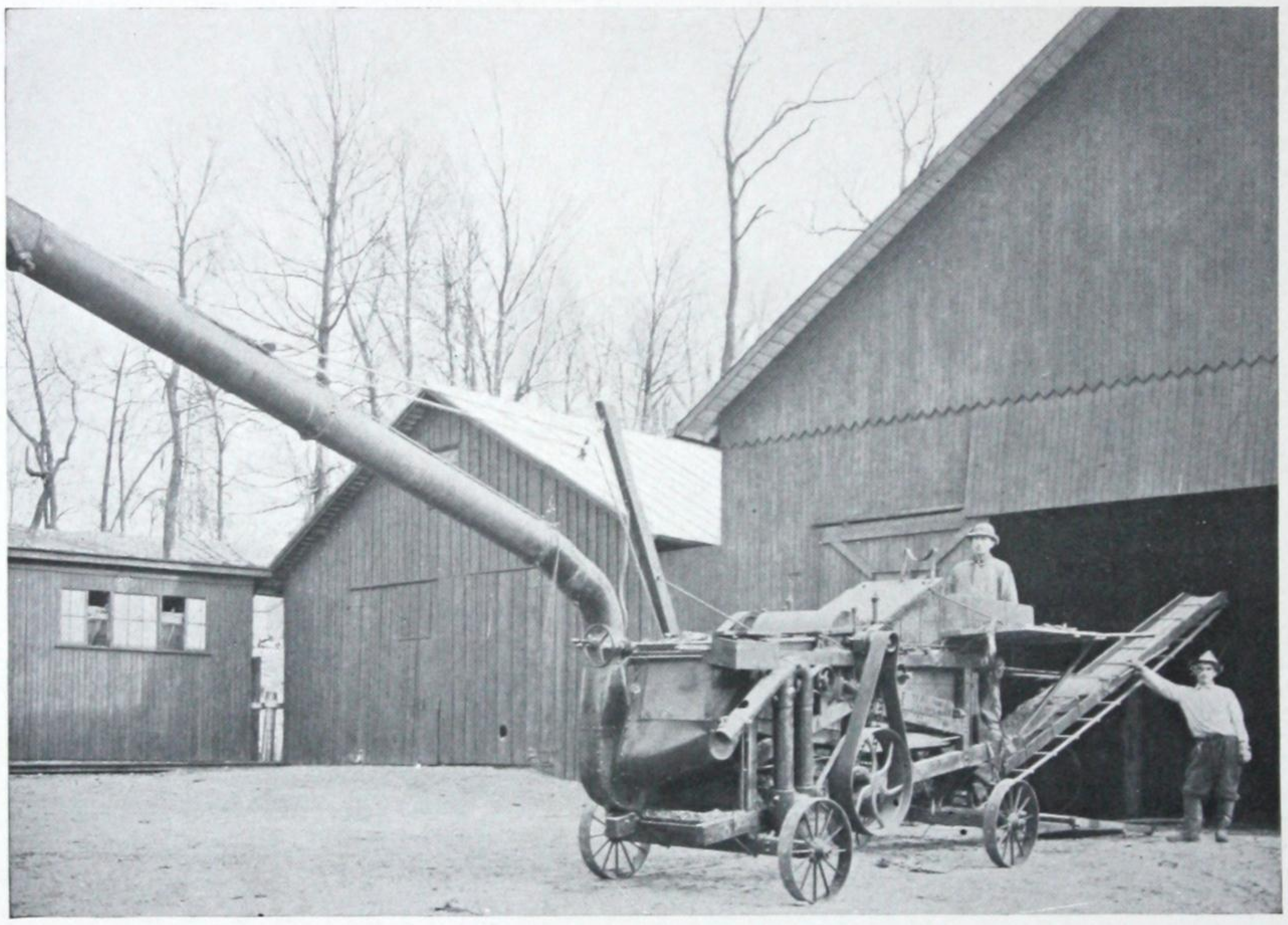
Water pumps
Feed grinders
Corn shellers
Ensilage cutters
Fanning mills
Cord wood saws
Grain elevators
Huskers and shredders
Corn crackers
Oat crushers
Alfalfa mills
Concrete mixers
Horse groomers
Horse clippers
Sheep shearers
Grain threshers
Hay cutters
Grain graders
Root cutters
Bone grinders
Hay hoists
Hay balers
Clover hullers
Rice threshers
Pea and bean hullers
Cider mills
Cider presses
Spraying machines
Clover cutters
Wood splitters

The machine shown below is operated by a 15 h.p. motor and requires about 5.4 kw-hr. to husk and shred a ton of fodder. At 5c a kw-hr. this would mean a cost of 27c. a ton.

If an ordinary conveyor had been used instead of the blower, the power consumption per ton would have been much less. The same motor is used to grind about 4000 bushels of feed per year and in addition all the wood used on the farm is sawed by electricity.

Mr. Stroop is an enthusiastic advocate of the use of electric power, and his home and dairy are completely equipped with all the latest electric devices.

The following table shows the results obtained from tests made on motor-driven machines under actual operating conditions, together with the power cost per bushel with electricity from 1c. to 10c. per kilowatt-hour.



Six-Roll Shredder and Husker Driven by a 15 H.P. Portable Motor on Farm of W. Stroop, Dayton, Ohio

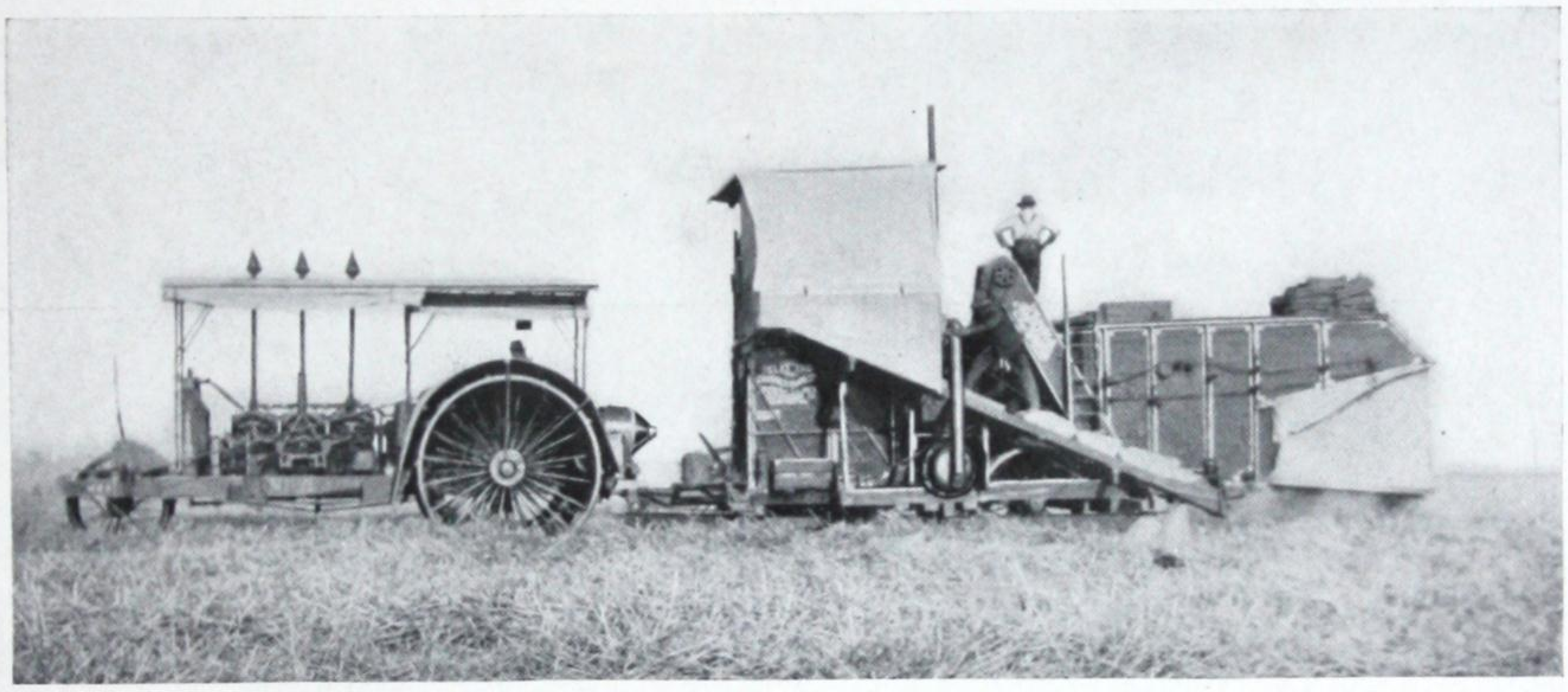
Operation	Capacity of Machine per hour in Bu.	H.P. of Motor Required	Kw-hr. Required per Bu.	Power Cost per Bushel with Electricity Costing from 1c. to 10c. per kw-hr.									
				1c.	2c.	3c.	4c.	5c.	6c.	7c.	8c.	9c.	10c.
Grinding corn on the cob	41	20	0.411	$0.0041	$0.0082	$0.0123	$0.0164	$0.0205	$0.0246	$0.0287	$0.0328	$0.0370	$0.0411
Grinding oats	5.7	3	0.37	0.0037	0.0074	0.0111	0.0148	0.0185	0.0222	0.0259	0.0296	0.0333	0.0370
Crushing oats	50	2	0.045	0.0004	0.0009	0.0013	0.0018	0.0022	0.0027	0.0031	0.0036	0.0040	0.0045
Grinding shelled corn	41.5	15	0.272	0.0027	0.0054	0.0082	0.0109	0.0136	0.0163	0.0190	0.0218	0.0245	0.0272
Grinding shelled corn	12.6	5	0.433	0.0043	0.0086	0.0130	0.0173	0.0216	0.0260	0.0303	0.0346	0.0390	0.0433
Cracking corn	65.8	7.5	0.086	0.0009	0.0017	0.0026	0.0034	0.0043	0.0052	0.0060	0.0069	0.0077	0.0086

All materials were ground or crushed as fine as they are ever used in farm practice. Therefore, the kilowatt-hours required to grind or crush a bushel as given in this table may be considered the maximum amount needed to perform this operation under average farm conditions. Tests were made with Dent corn, Flint corn will take a little more power per bushel.

The combined harvester illustrated below is equipped with an 80 h.p., six-cylinder gas traction engine, which, in addition to supplying motive power for the tractor, drives a 20 kw. generator through belting. The traction engine is controlled through a flexible clutch and can start or operate at various speeds without affecting the speed of the generator.

Hooked to the traction engine is a combined harvester which cuts, threshes, and re-cleans wheat, oats or barley, and delivers the product into sacks ready for the market. A 25 h.p. motor drives the entire mechanism, and is connected by a flexible coupling to the threshing cylinder; the other sections of the machinery being operated through gears and chains.

The crew required for the operation of this outfit consists of an engineer, two sack sewers, one tender, and one header man who manipulates the header which cuts the



CLB Gas and Electric Harvester in Operation on a California Farm Showing Arrangement of Electric Generator and Motor

grain. Marked operating economies have been obtained and, with all allowances for up-keep and depreciation, this outfit has reduced the cost of harvesting to approximately 60 cents per acre, thereby effecting a saving of at least $2.00 per acre when compared with the ordinary methods of harvesting.

To a certain extent these results have also been accomplished by combined harvesters which were steam-driven, but they entailed extra operating expense for fireman, water hauler, and the hauling of fuel. In addition to this, the boiler fires of the steam-driven outfits were always a potential source of fire risk, this danger being entirely absent in the electrically-operated harvester.

In order to protect the generator and motor, and thoroughly to exclude dust and dirt, both machines are totally enclosed and arranged for forced ventilation. The entire electrical equipment of this harvester is of General Electric manufacture, and under normal operating conditions its production averages approximately 2200 bushels per day of ten hours.

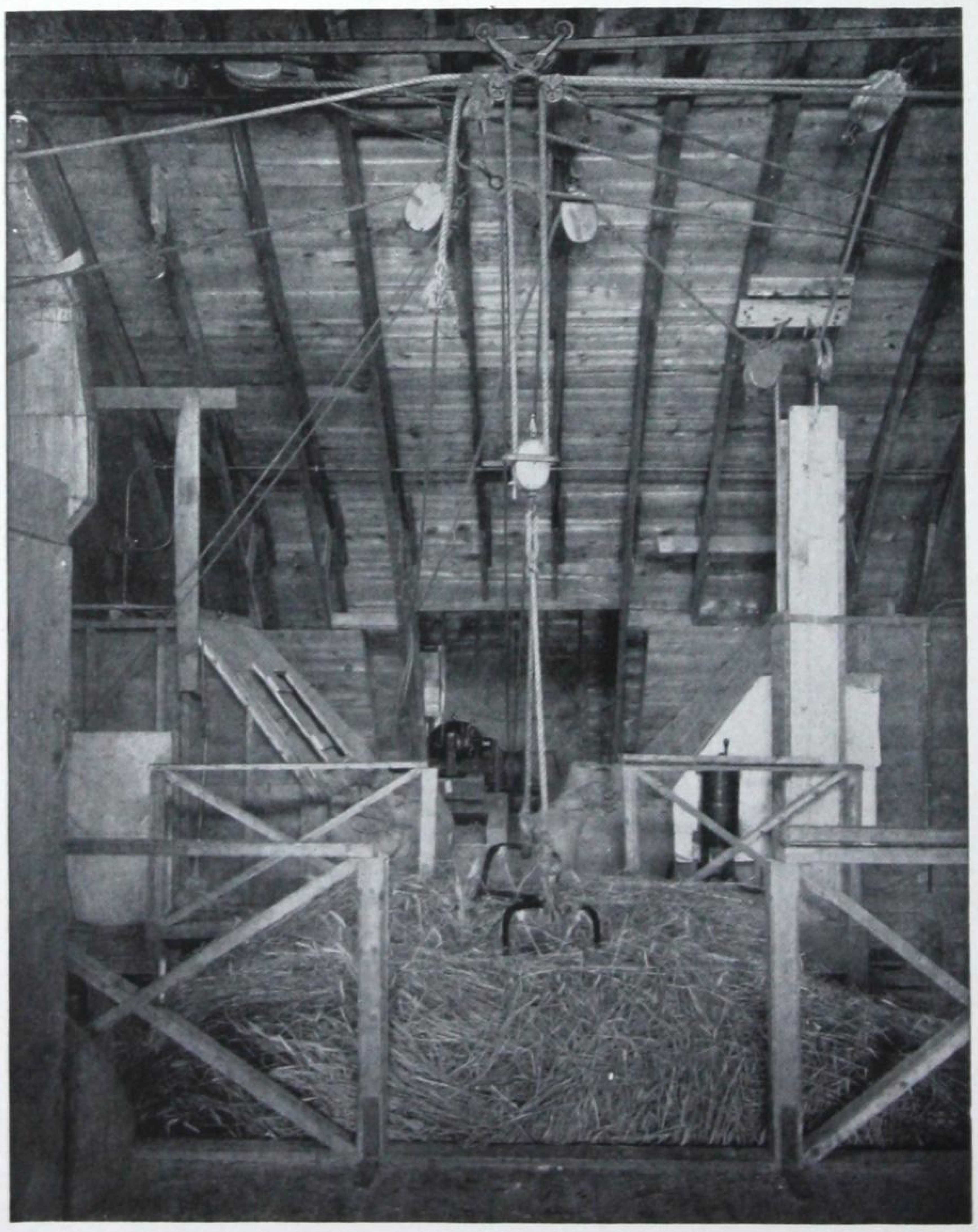
Too often the farmer loses sight of the fact that it costs him anywhere from one to six cents a bushel to haul his grain to and from the mill, depending on the distance.

A team of horses, under average conditions, will not travel faster than 2¼ miles per hour with a heavy load, say 54 bushels of shelled corn, 80 bushels of oats, or 43 bushels of ear corn. It will require at least one hour to load the wagon at the farm, unload and reload at the mill, and then unload the ground feed at the farm. A man and team are worth on an average $3.50 a day.

Taking the above figures as a basis the following table shows the cost of hauling grain to and from the mill.

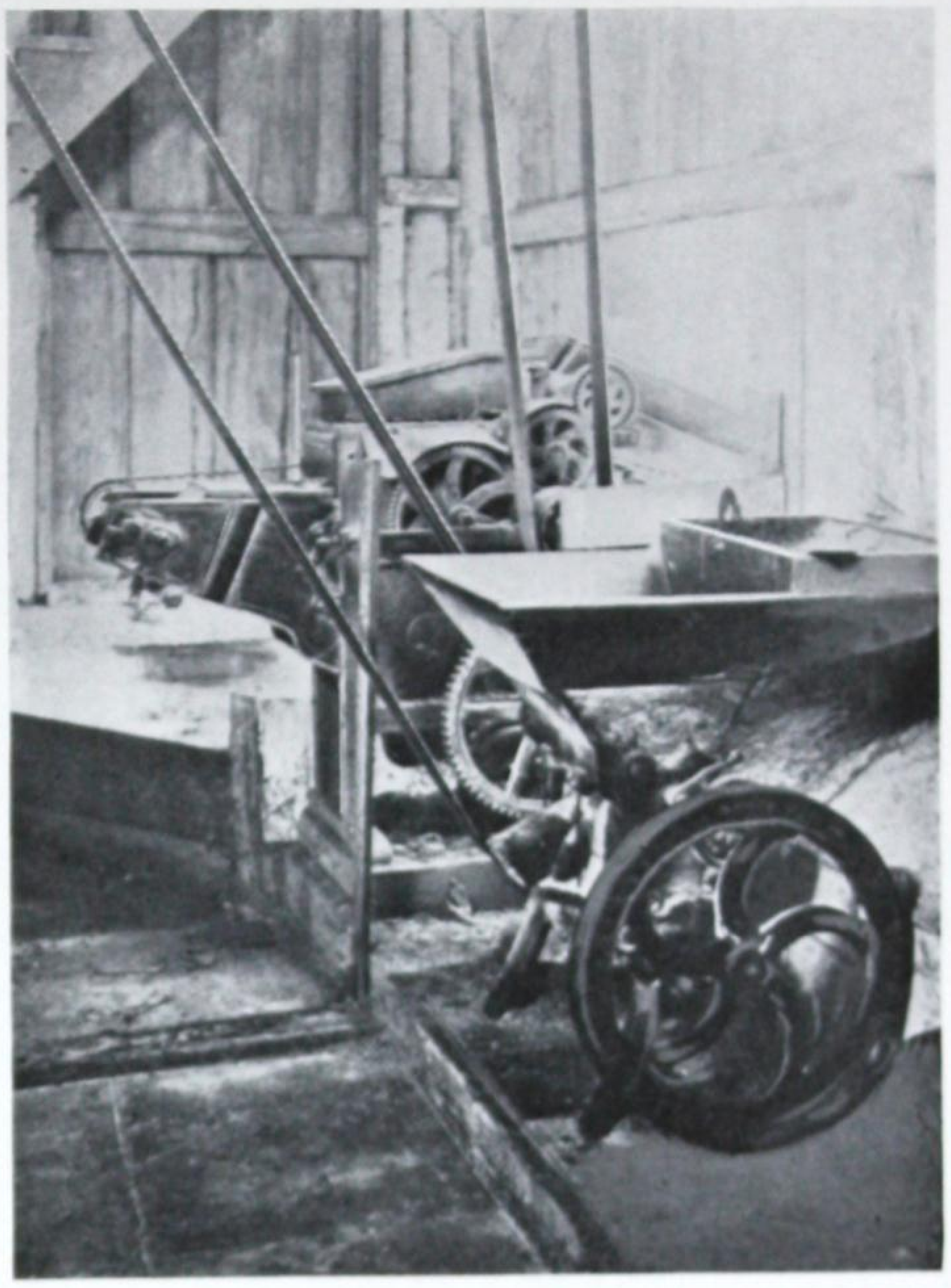
Cost per Bushel for Hauling to and from the Mill

Distance in Miles from Farm to Mill	Corn (Shelled)	Corn on Ear	Oats
1	1.22c.	1.54c.	0.83c.
2	1.8	2.26	1.21
3	2.38	2.99	1.6
4	2.96	3.71	2.0
5	3.53	4.45	2.39
6	4.1	5.15	2.77
7	4.7	5.9	3.16



Motor-Operated Hay Hoist and Controller

5 H.P. Motor Belted to Concrete Mixer. Frank Heffer's Farm, Irondequoit, N. Y.



Corn Sheller and Corn Grinder Belt-Operated by Motor. University of Illinois Dairy Barn

Size of motors to use on the different farm machines:

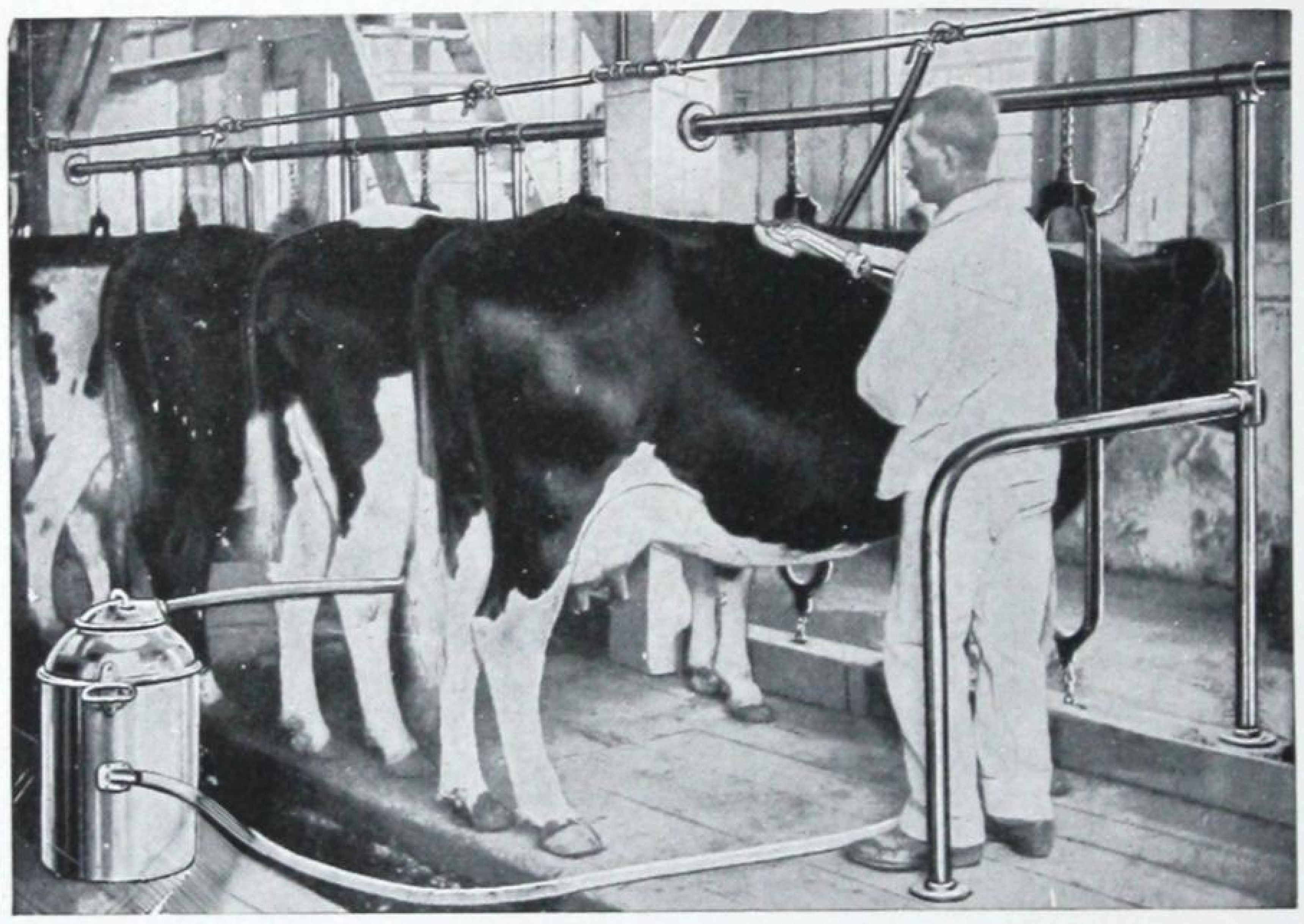
Machines	H.P. of Motor Min.	H.P. of Motor Max.	H.P. of Motor Size Most Commonly Used on Average Farms
Feed grinders (small)	3	10	5
Feed grinders (large)	10	30	15
Ensilage cutters	10	25	15–20
Shredders and huskers	10	20	15
Threshers, 19 in. cylinder	12	18	15
Threshers, 32 in. cylinder	30	50	40
Corn shellers, single hole	3/4	1 1/2	1
Power shellers	10	15	15
Fanning mills			1/4
Grain graders			1/4
Grain elevators	1.5	5	3
Concrete mixers	2	10	5
Groomer, vacuum system	1	3	2
Groomer, revolving system	1	2	1
Hay hoists	3	15	5
Root cutters	1	5	2
Cord wood saws	3	10	5
Wood splitters	1	4	2
Hay balers	3	10	7 1/2
Oat crushers	2	10	5

In the operation of corn shellers, fanning mills, grain graders, etc., very little power is usually required, and a motor of small capacity will insure constant operating speed and can be readily handled in the form of a portable equipment, so that a single motor can be utilized to drive all machines of this class in the farm equipment.

A single hole sheller with a sacker attachment when driven by a 1 h.p. motor requires about 0.025 kw-hr. of electricity to shell a bushel of ear corn at a rate of 26 bushels per hour. Even with electric current at 10 cents per kilowatt-hour the power cost for this operation would only be ¼ of a cent per bushel. Fanning mills and grain graders require less power than corn shellers for operation and a ¼ h.p. motor is usually of ample capacity for this service.

It has been found by test that a motor-driven grain elevator, capable of unloading a 25-bushel load of ear corn in three minutes, will elevate 45 bushels 19 ft. at a power cost of 1c., power being purchased at the rate of 10c. per kilowatt-hour. This does not include a horizontal carry at the top which would slightly increase the cost.

The common types of portable grain elevators require anywhere from 1.5 to 5 h.p. to operate them, depending on the height of the lift, the length of the horizontal carry, and the number of loads which can be disposed of in an hour.



Using a "Burrell" Vacuum Cattle Cleaner

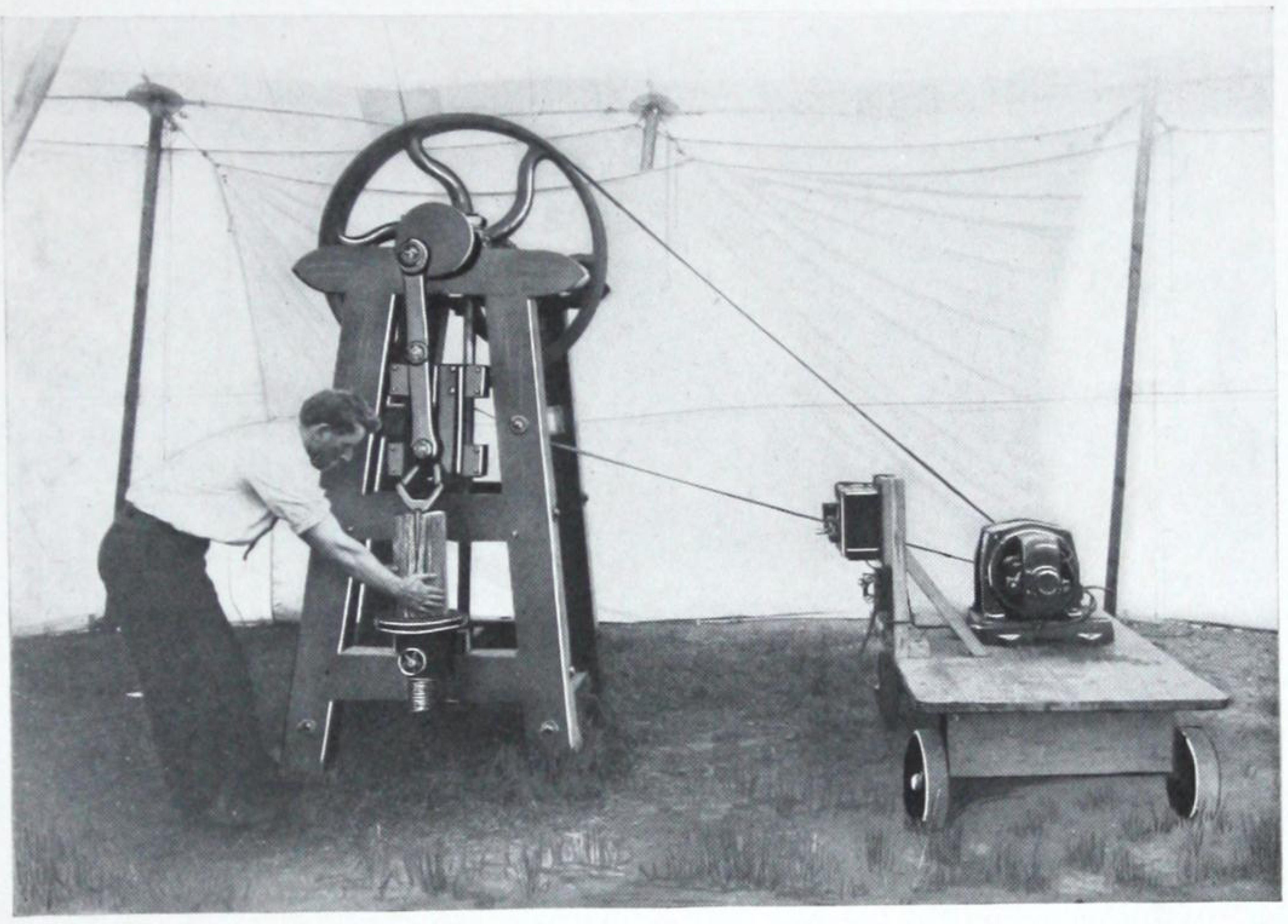
One of the most frequent sources of contamination of milk is the dirt and hair from the hide of the cow. When cattle are cleaned in the ordinary way, dirt is stirred up and flies about the stable. Where a vacuum pump is used this may be avoided by utilizing vacuum tools for cleaning the cattle. These tools can be connected to the milking machine vacuum piping system and the dirt drawn off from the cows' hide and gathered into a dust collector. This outfit is equally useful for grooming horses.

The revolving type of groomer can be electrically operated at very low cost and clipper and shearer may also be attached. With this type it costs about 0.6c. to groom one animal and with the vacuum type about 1.2c. with electricity at 10c. per kilowatt-hour; allowing five minutes per animal for the grooming operation.

When using a compressed air sprayer the operation of the air compressor by means of an electric motor will reduce the cost of spraying, inasmuch as the motor-driven outfit does not require mechanical knowledge on the part of the operator, and the man who is mixing the chemicals can readily take care of the air charging outfit as well.

The life of such an equipment is greater than that of a sprayer which has the engine mounted on the wagon. The electrical outfit also has the advantage of automatic operation.

The motor-operated hay hoist illustrated on page 28 is a good example of the saving in labor which may be obtained by the use of motor drive in barns, as well as the safety with which electric motors may be installed and operated in proximity to combustible materials. This hoist is operated by a 10 h.p. motor which drives it through gears, and a simple drum controller is used to regulate the hoisting and traveling speeds. With this hoist two men can elevate and store the hay; the entire operating time for a one ton load averaging less than five minutes.



Wood Splitter Operated by Portable Motor

Root cutters for cutting up rutabagas, turnips, pumpkins, and mangels are used quite extensively by dairymen throughout the United States. These machines require very little power, a 2 h.p. motor being sufficient to drive a cutter having a capacity of about 6 tons per hour.

With electricity at 10c. per kw-hr. the power cost would only be about 1.6c. per ton.

On farms raising poultry electric current can be used to advantage for the operation of incubators and brooders. An electrical incubator is superior to all other types, in that it supplies a uniform heat which can be automatically regulated, and when once the switch has been turned it requires no further attention. Heating by electricity eliminates the necessity for supplying and handling fuel, and as oxygen is not consumed its operation does not vitiate the air. A 60-egg incubator requires about 11 kw-hours to hatch a setting of eggs. A 250-egg incubator takes about 16 kw-hours per hatch.

For sawing up cord wood a motor can be utilized to drive the saw and can be either direct connected to the saw shaft, or drive through a belt. Saws thus equipped can be located out of doors, if necessary, inasmuch as electric drive is unaffected by low temperatures, and power is therefore available under all weather conditions.

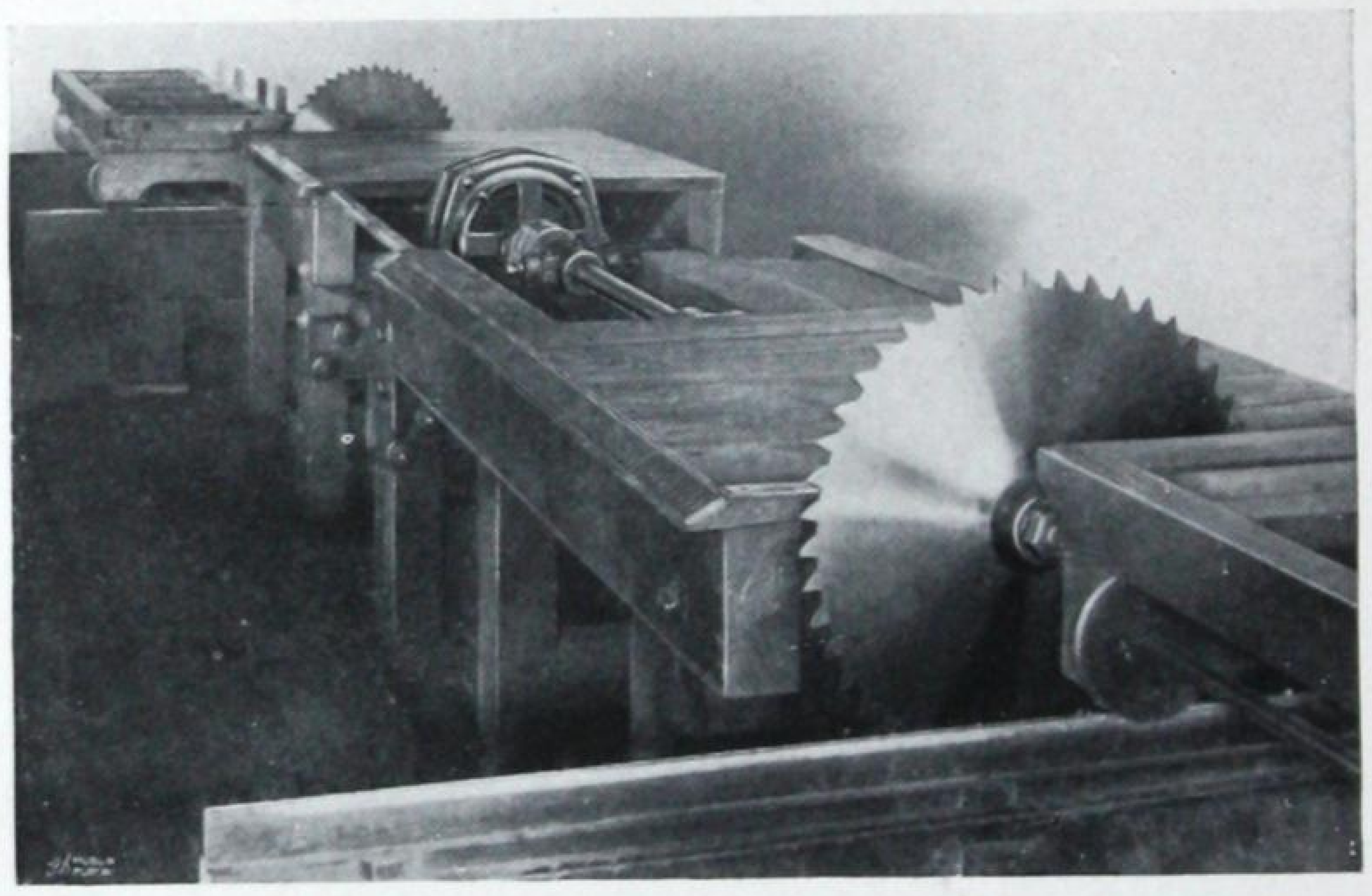
The wood splitter shown herewith is extremely simple in operation, and will insure a great reduction in both time and labor required in splitting wood to usable sizes.

Motor Drive in the Farm Work Shop

Every farm occasionally requires carpentry or wagon repair work and is usually equipped with woodworking machinery. The serviceability and economy of motor drive for this class of work has led to its general adoption in saw mills and other woodworking plants, and it will be found equally valuable for driving the machinery of farm repair shops.

For operating circular saws the motor can usually be direct connected to the saw shaft, and for lathes, band saws, planers, etc., either direct connection or belt drive may be used. On some farms it is the practice to belt connect all the woodworking machines to a main shaft, which is driven by a single motor; in others each machine is supplied with its own motor connected in the manner shown in the accompanying illustrations.

Using a G-E Portable Breast Drill



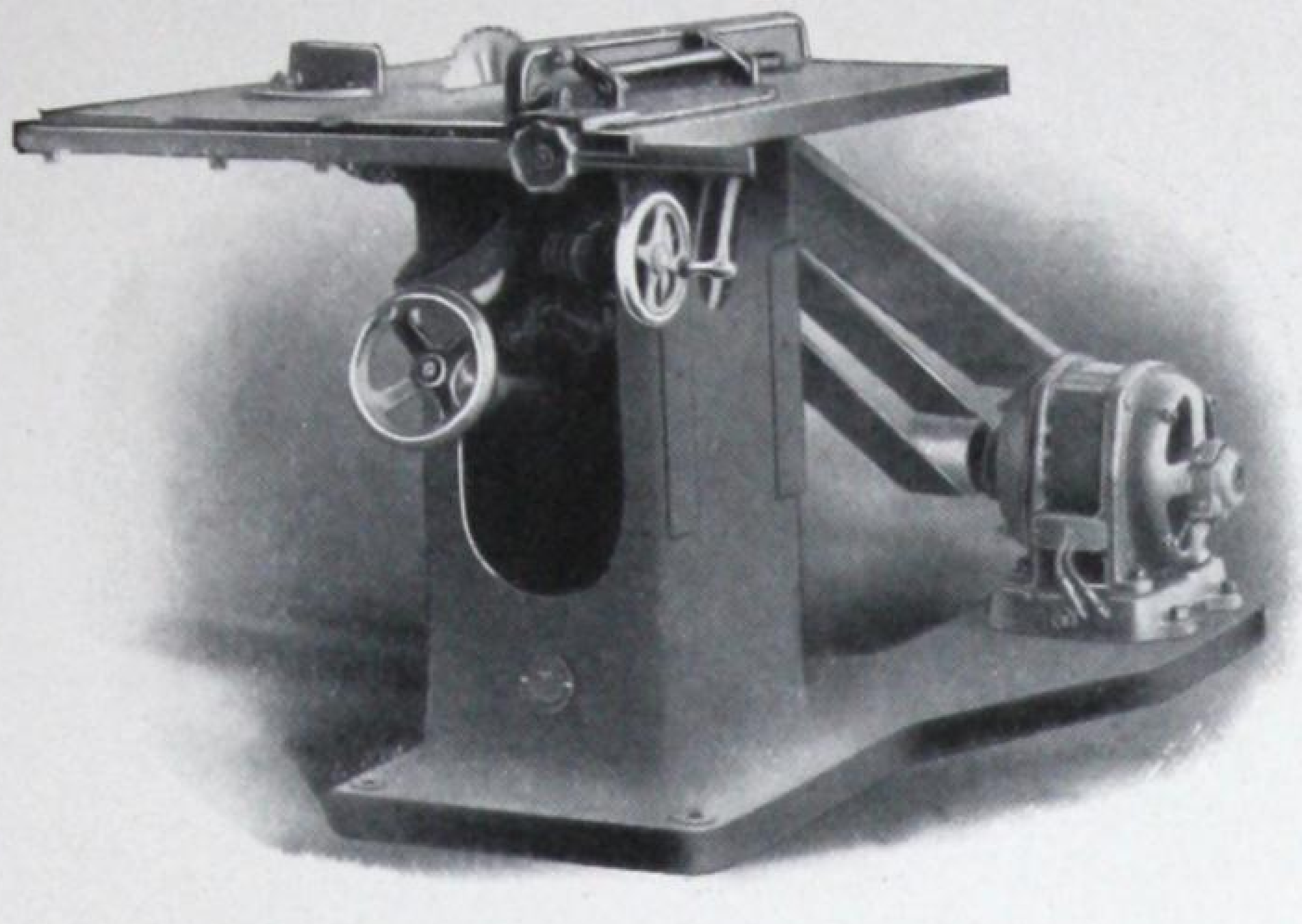
7½ H.P. Induction Motor Direct Coupled to Two 20-Inch Circular Cross Cut Saws

For sharpening tools the ordinary grindstone may be provided with motor drive, or small compact high speed grinding wheels may be direct connected to the shaft of a small motor which can be installed on the work bench.

Where the equipment includes metal working machinery it is advisable in practically every case to provide each machine with its own motor, which can usually be mounted on the machine and drive through gearing.

In the blacksmith shop motor-driven forge blowers permit a more positive control of the forge blast than that obtained with any hand operated mechanism, and small electrically-operated drop hammers can be utilized to reduce manual labor and insure a more rapid handling of the work.

The electric soldering iron, portable drill and the smaller sized glue pots can be used to great advantage about the farm, as they can be easily connected to the nearest electric lamp socket. Many farmers, who do winter painting, use an electric glue pot to keep the paint warm.



Induction Motor Driving Saw Table

One cent's worth of electricity at 10c. per kilowatt-hour:

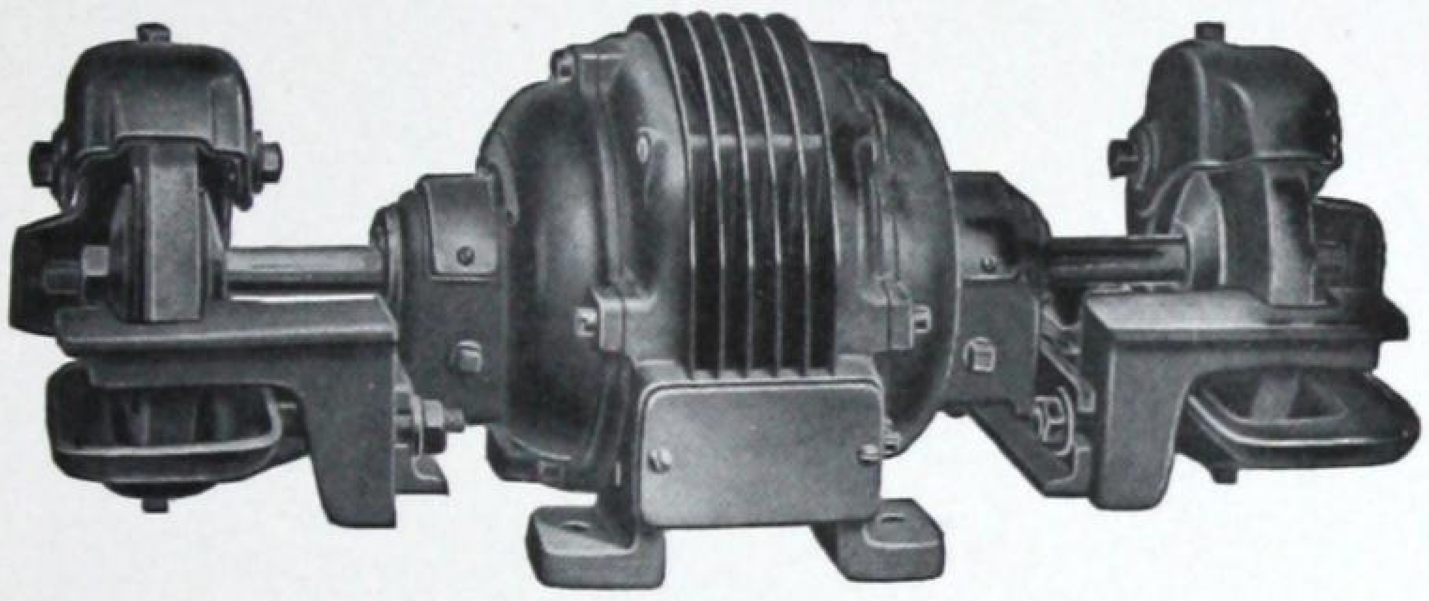
Will keep a one-pound soldering iron hot for forty minutes

Will keep a half-pint glue pot hot for five hours

Will operate the ordinary farm grindstone or emery wheel thirty minutes.

Will drive a farm forge blower for two hours

Will operate a portable drill from twenty minutes to one hour depending on conditions.



Motor-Driven Grinding Set

Electric Gluepot
(It Has No Water Jacket)

Electric Soldering Iron

Twelve Uses for Electricity in the Farm Shop

Grindstones	Forge blowers
Leather burnishers	Drop hammers
Emery wheels	Soldering irons
Wood saws	Glue pots
Hack saws	Lathes
Drills	Planers

Size of motors to use on different farm machines:

Machines	H.P. OF MOTOR		
	Min.	Max.	Size Most Commonly Used on Average Farm
Grindstone	1/8	1/4	1/4
Emery wheel	1/4	1	1/4
Lathes	1/4	1/2	1/2
Forge blowers	1/15	1/8	1/10

Bench Drill Driven by 1/6 H.P. Motor

Electric Vehicles on the Farm

Where electric current is available the motor-operated vehicle constitutes an important addition to the farm equipment. For the class of service required on farms they are superior to the engine-driven type, inasmuch as they have fewer parts, none of which require adjustments by the operator, and the simple controlling apparatus permits of a maximum range in speed variation without the use of gears.

There is an entire absence of the heat and dirt which usually accompany the operation of engine-driven vehicles, and the operating and controlling mechanism is so simple that either pleasure or working vehicles of this type can be safely handled by women.

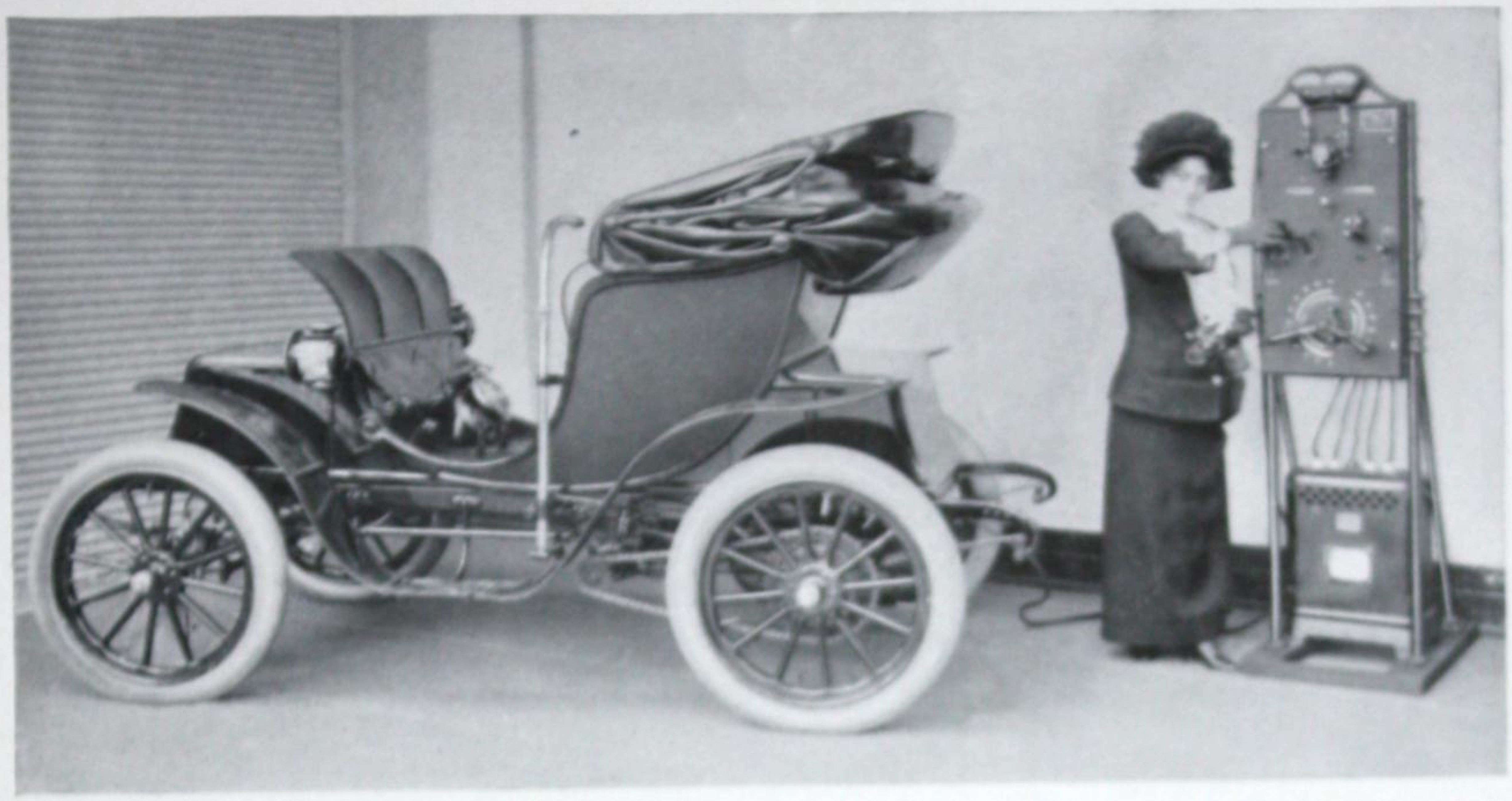
In regard to tractive efficiency, the driving motors have such overload capacity that

3½ Ton Electric Truck Used in Harvesting

electrically-operated vehicles can start heavier loads, and climb steeper grades than engine-driven vehicles of the same horse-power rating.

The 3½ ton electric truck shown above is a good example of the practical value of electric vehicles on the farm. It is ordinarily used in delivering produce to the depot, but during the harvest season it is utilized in the manner shown for gathering hay and wheat.

A comparison of the loads of the horse-drawn and electric wagons will indicate the superiority of the latter, and in addition to its greater capacity, it can be safely used on practically any farm land; it has greater speed than the horse-drawn vehicle, and can therefore make a greater number of trips in a given time. The load of wheat which is shown herewith consists of 617 bundles, which after being threshed yielded 45 bushels, the regular two-horse load being only 260 bundles.

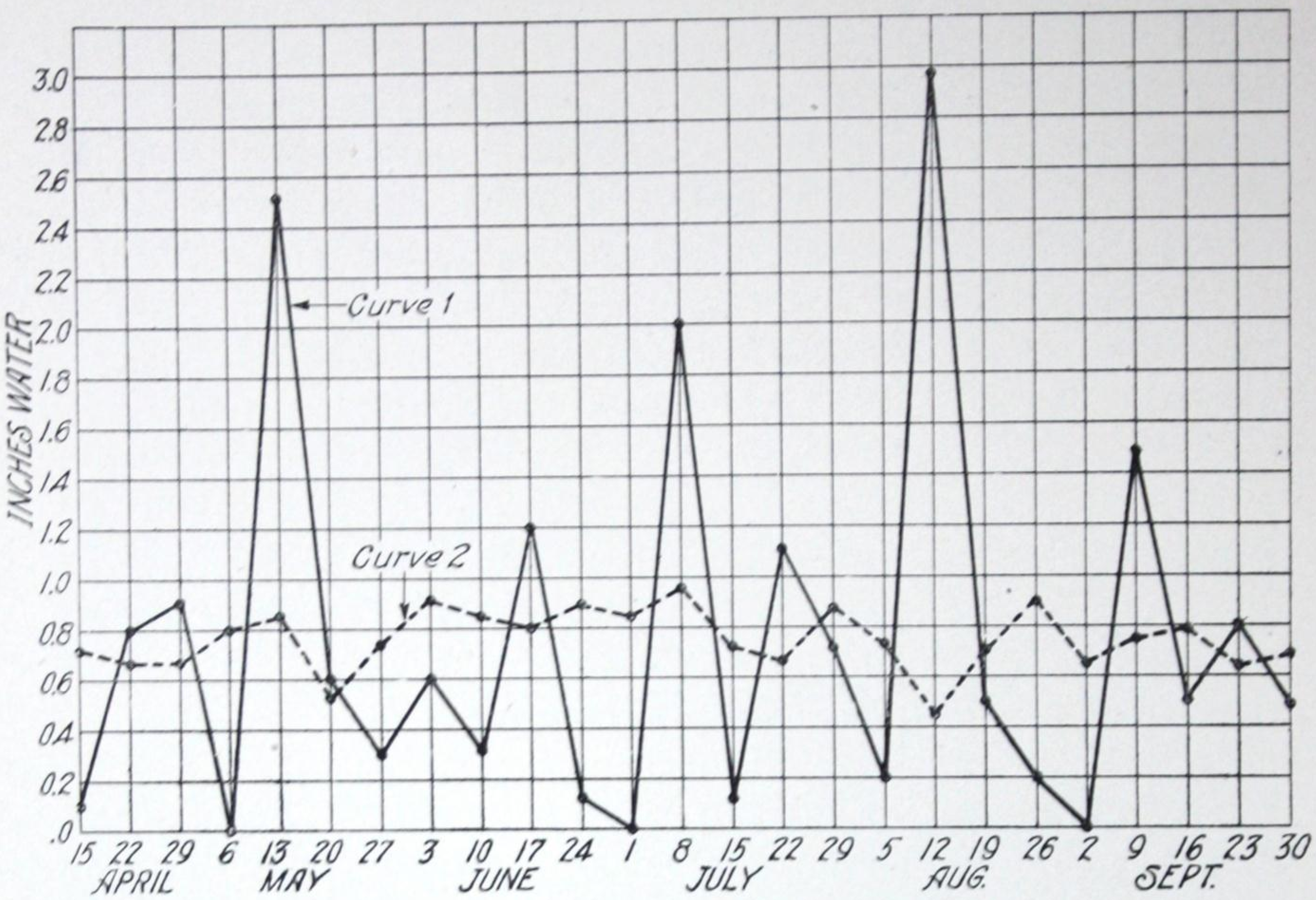


Charging the Batteries of an Electric Vehicle

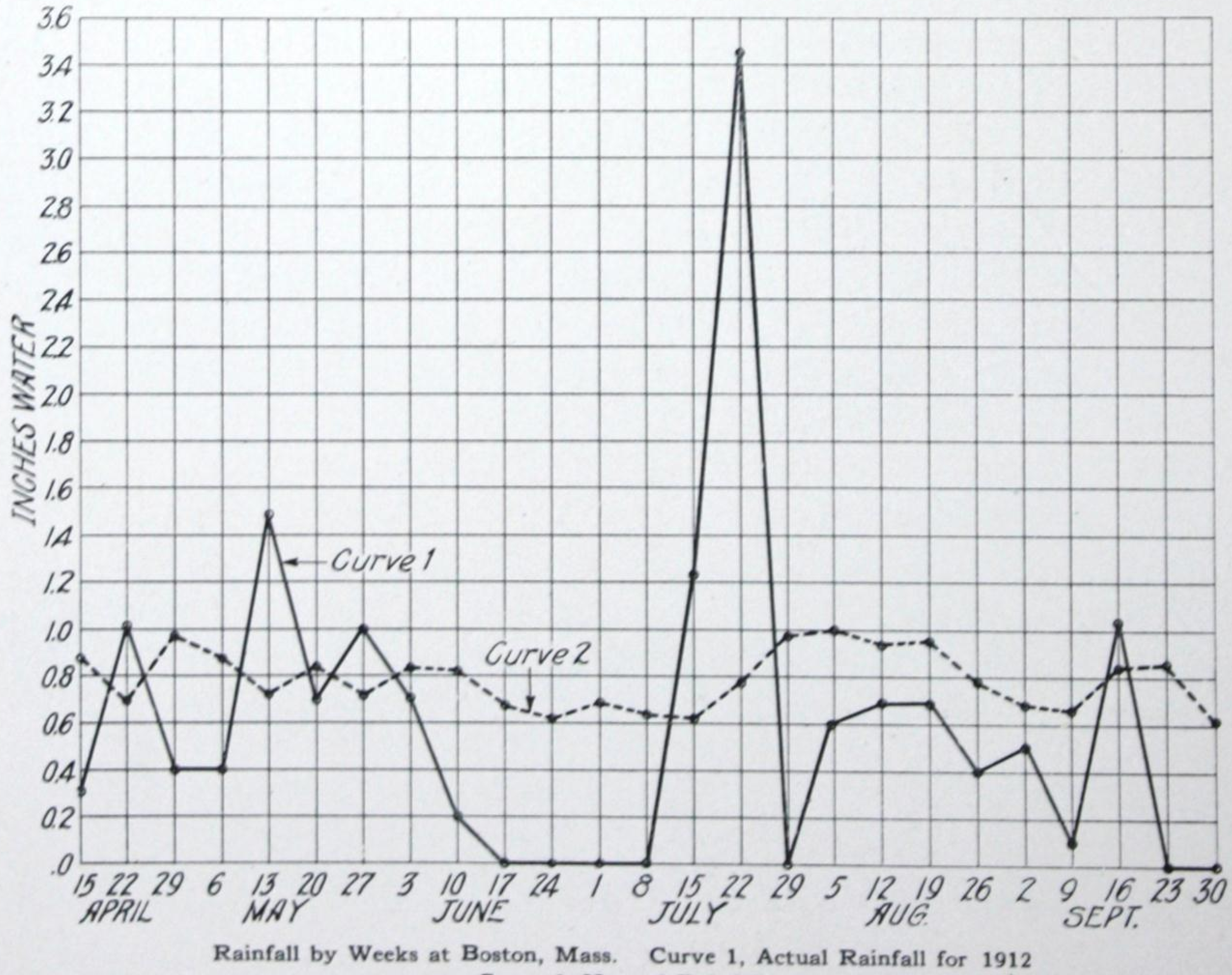
Where the time element in getting the wheat to the thresher due to variable conditions of the weather is important, an electric truck of this type may become a very valuable feature of the farm equipment.

With such trucks, farms which are remote from a railroad, and can, therefore, be bought cheaply, can be made almost as valuable as farms near the cities. In fact, they will no longer be far away. Their proximity will be measured not by miles but by hours, and the ability quickly to deliver grain or other products to the nearest railway station will place the farmer in a far better position to get the best prices in a market that is continually changing.

Electric Vehicle at the Boston Farm Electrical Exhibit



Rainfall by Weeks at Chicago, Ill. Curve 1, Actual Rainfall for 1912
Curve 2, Normal Rainfall



Rainfall by Weeks at Boston, Mass. Curve 1, Actual Rainfall for 1912
Curve 2, Normal Rainfall

Irrigation

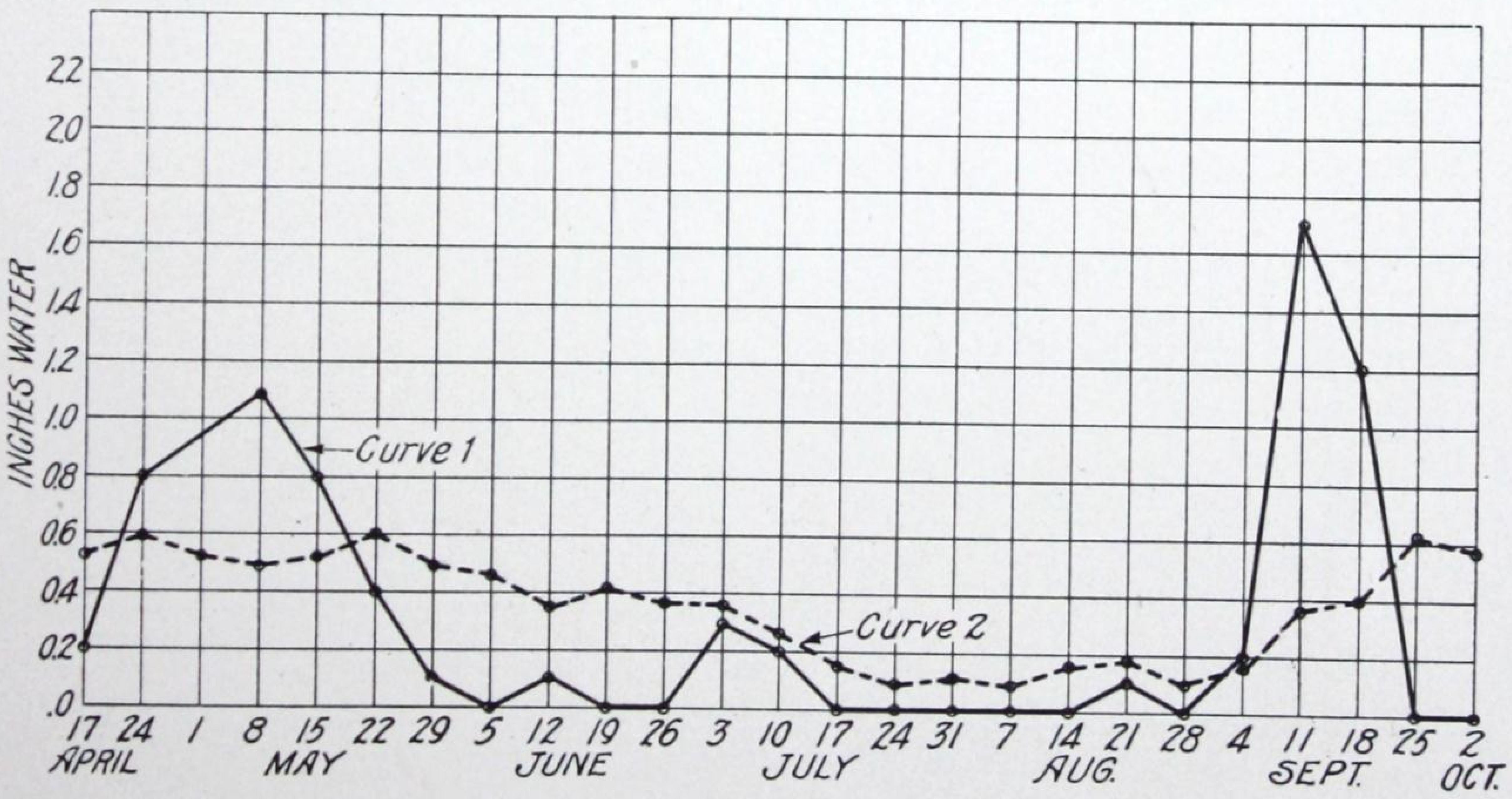
Water is a necessity for the growth of every crop. In the western states, the rainfall is, as a rule, insufficient to support even a scant growth of vegetation, but in the central and eastern states the average rainfall during the growing season is ordinarily considered sufficient. However, in the latter sections of the country hardly a year passes without some particular section being badly in need of rain.

As rains, to be beneficial, must come at such times and in such amounts as will properly moisten the soil and produce growth, a check in this supply of soil moisture at any stage of the growth affects both the quality and quantity of the yield and may greatly reduce the profits of the grower. The real test of the necessity of irrigation is not the total annual rainfall, but the monthly, and, in the case of most crops, the weekly amount of precipitation throughout the growing season. Under average conditions, it is safe to say that a drought occurs whenever the rainfall totals less than one inch in any fifteen day period, and crops will usually suffer if they do not receive more than this amount of rain, especially during the spring and early summer months.

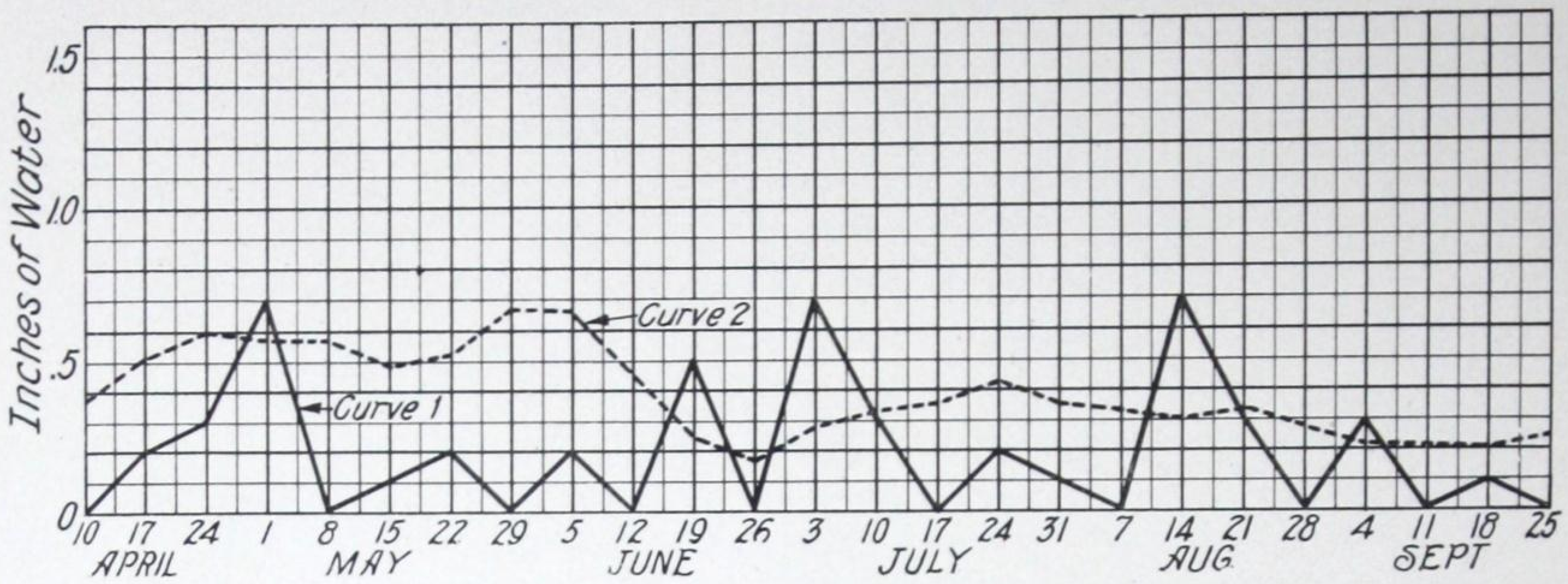
The following table compiled from rainfall records of the Weather Bureau taken at respective points in the humid regions during ten growing seasons, 1900 to 1909 inclusive, shows the average annual rainfall, the number of periods of fifteen days in the ten years that droughts extended from the fifteen day periods.

	Average annual rainfall in inches	Number of 15-day periods or over with less than 1 inch of rain	* Number of days when irrigation was required
Ames, Iowa	30.39	23	190
Oshkosh, Wis.	29.78	27	292
Vineland, N. J.	47.47	46	352
Columbia, S. C.	47.55	62	568
Selma, Ala.	50.75	60	724

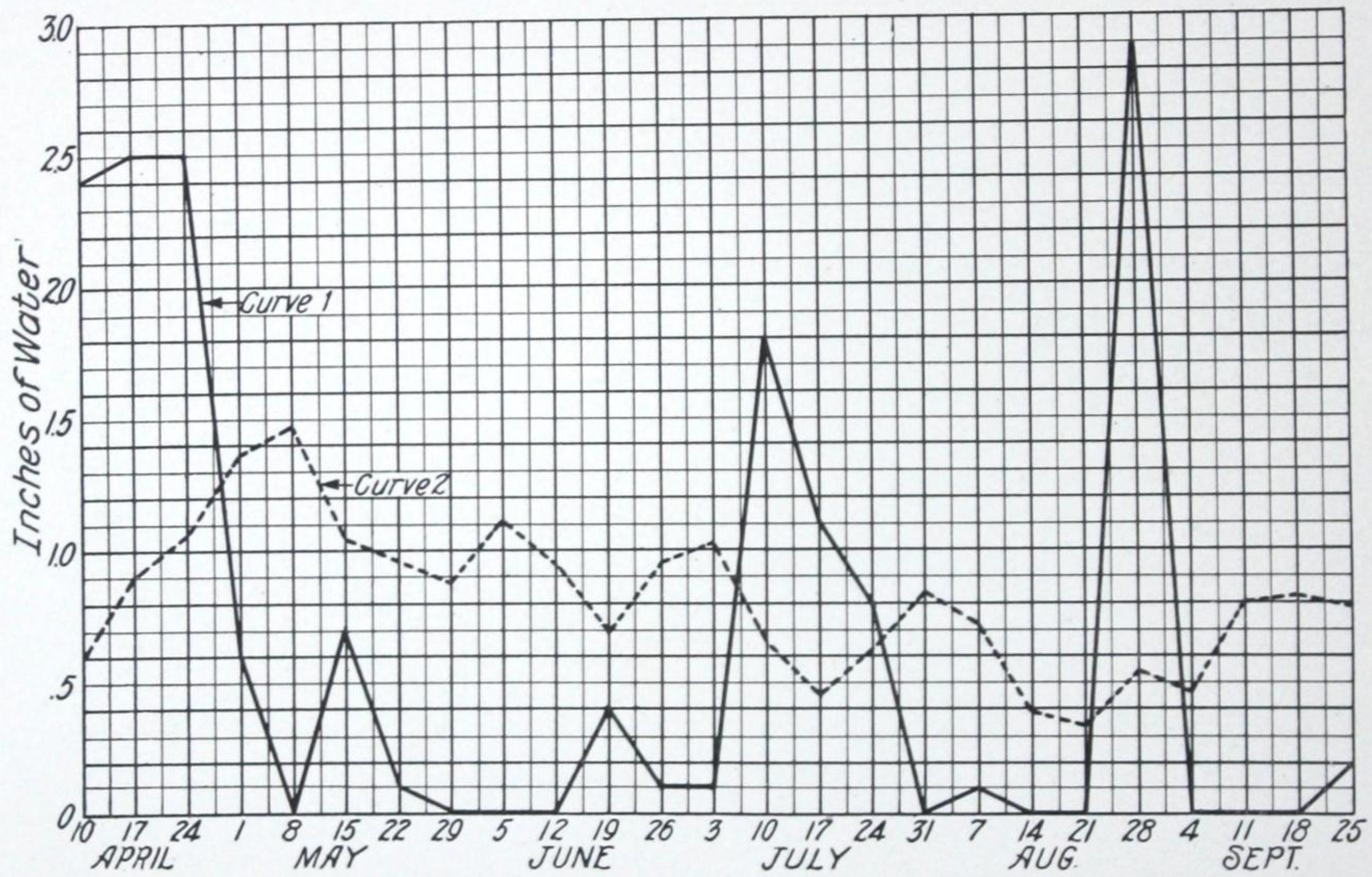
* No days counted till after a 15-day period with less than 1 inch of rain.



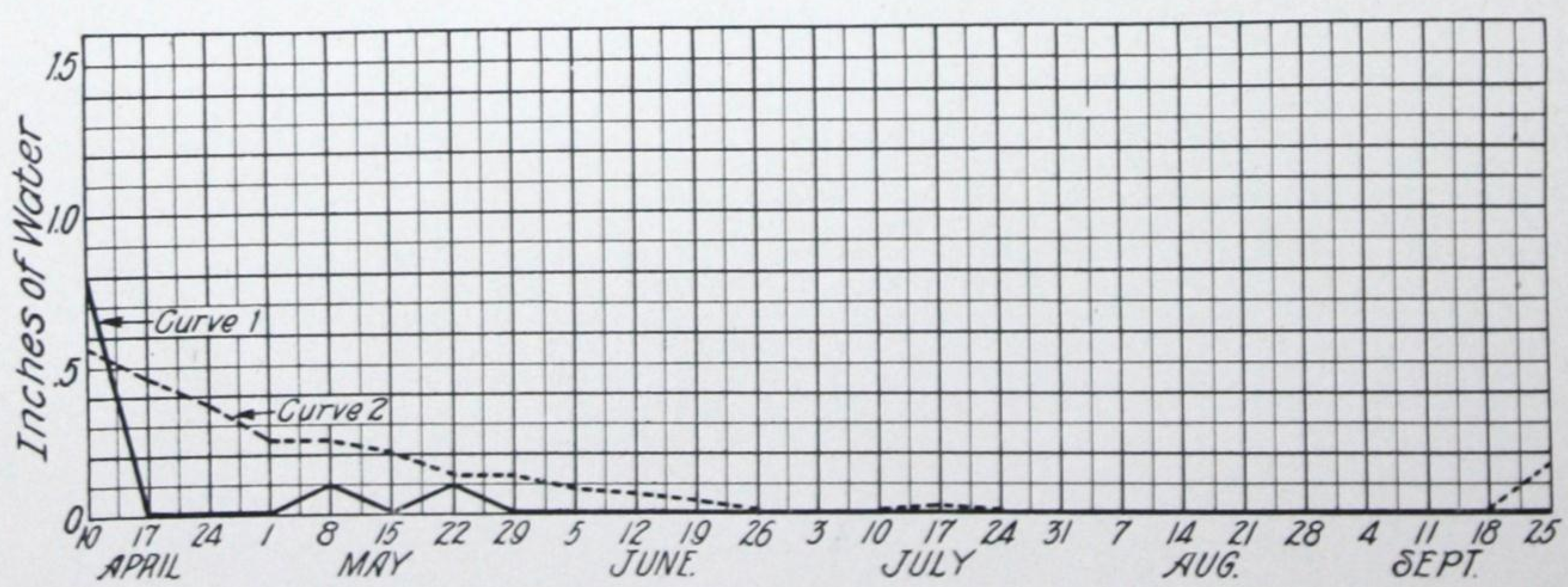
Rainfall by Weeks at Seattle, Wash. Curve 1, Actual Rainfall for 1912
Curve 2, Normal Rainfall



Rainfall by Weeks at Denver, Colo. Curve 1, Actual Rainfall for 1911
Curve 2, Normal Rainfall



Rainfall by Weeks at Palestine, Texas. Curve 1, Actual Rainfall for 1911
Curve 2, Normal Rainfall

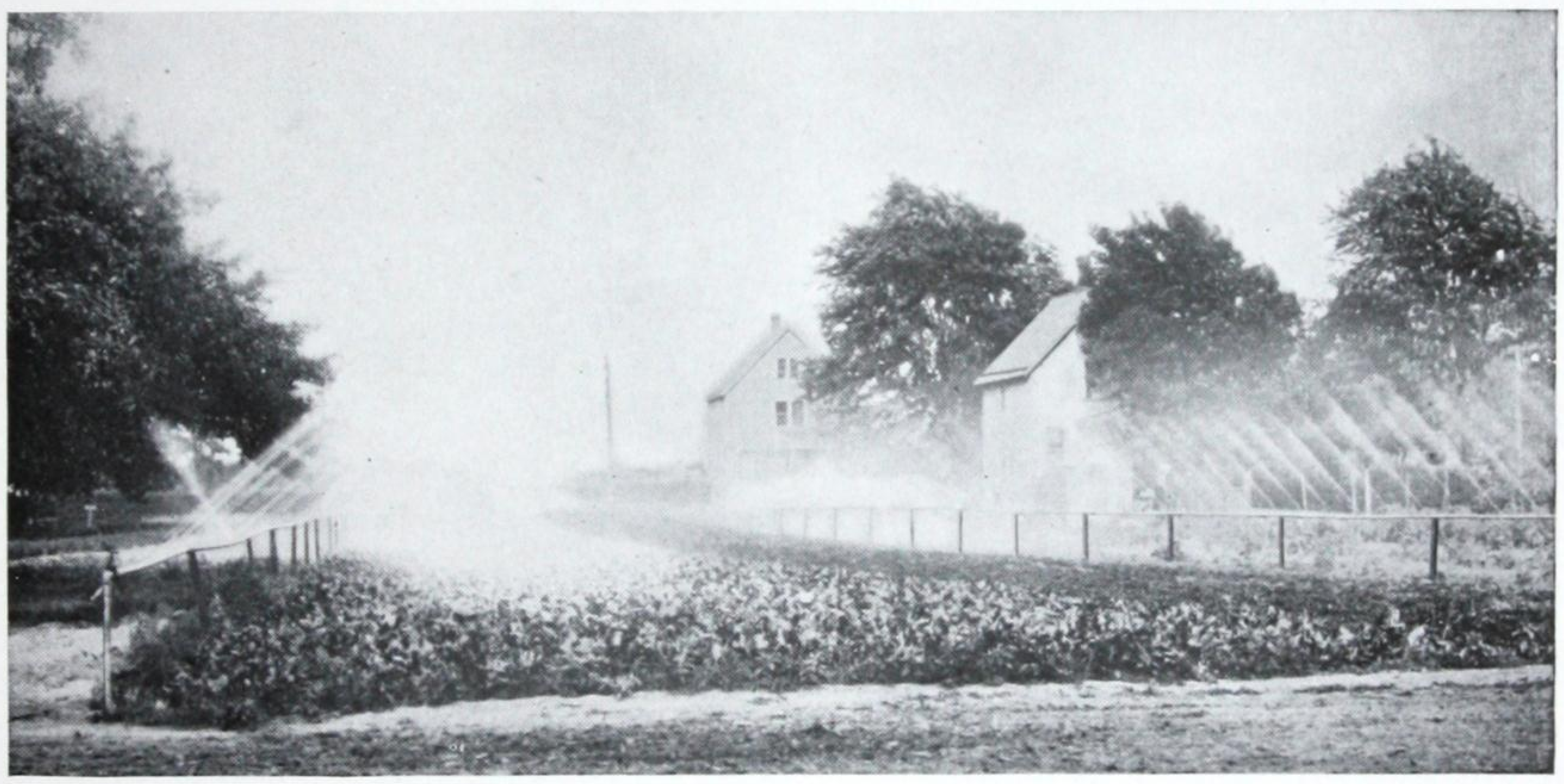


Rainfall by Weeks at San Francisco, Cal. Curve 1, Actual Rainfall for 1911
Curve 2, Normal Rainfall

The curves on pages 36, 37 and 38 from Boston, Mass.; Chicago, Ill.; Seattle, Wash.; Denver, Colo.; San Francisco, Cal., and Palestine, Texas, show how irregular the rainfall is during the summer months, as all of them show periods of drouth, i.e., less than 1 in. of total rainfall in two weeks. Curve No. 1 is the actual rainfall by weeks, curve No. 2 the average rainfall for a series of years.

Therefore, some artificial means of supplying water to the land is a necessity in the western section, and would be excellent insurance in the central and eastern parts of the United States.

Two general methods of supplying this water are now in use: The ordinary gravity flow, such as that of taking water from a reservoir or ditch; and the mechanical lift, such as pumping water from a well, pond, river or lake. Of the two, the development of the mechanical lift has been far more rapid. There are two reasons for this: *First*, because land which can be economically irrigated by the gravity method has been practically all taken up; and *second*, because the farmer can pump water to almost any elevation,

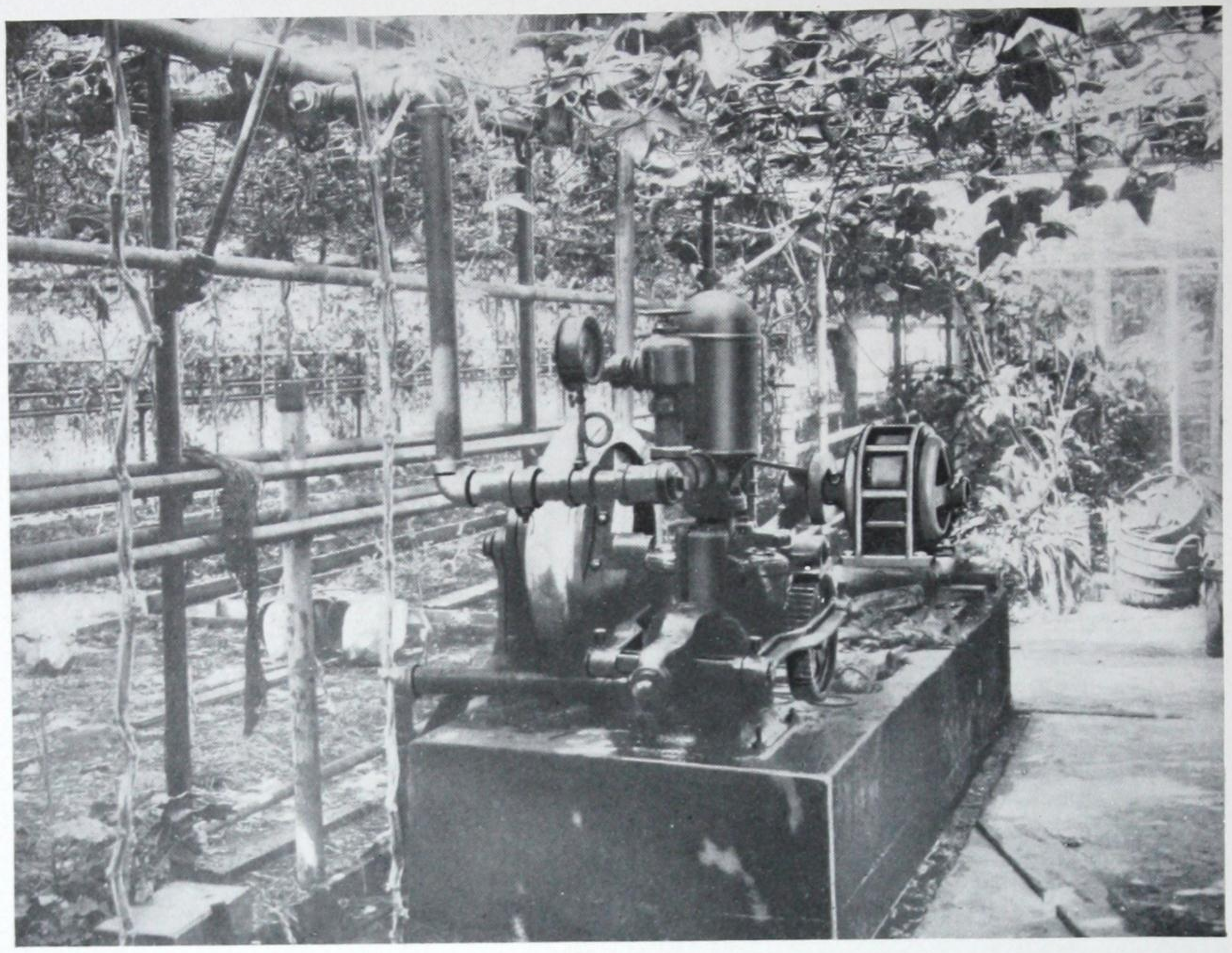


Market Garden Irrigated by Electric Power. Farm of F. Hallaner, Irondequoit, N. Y.

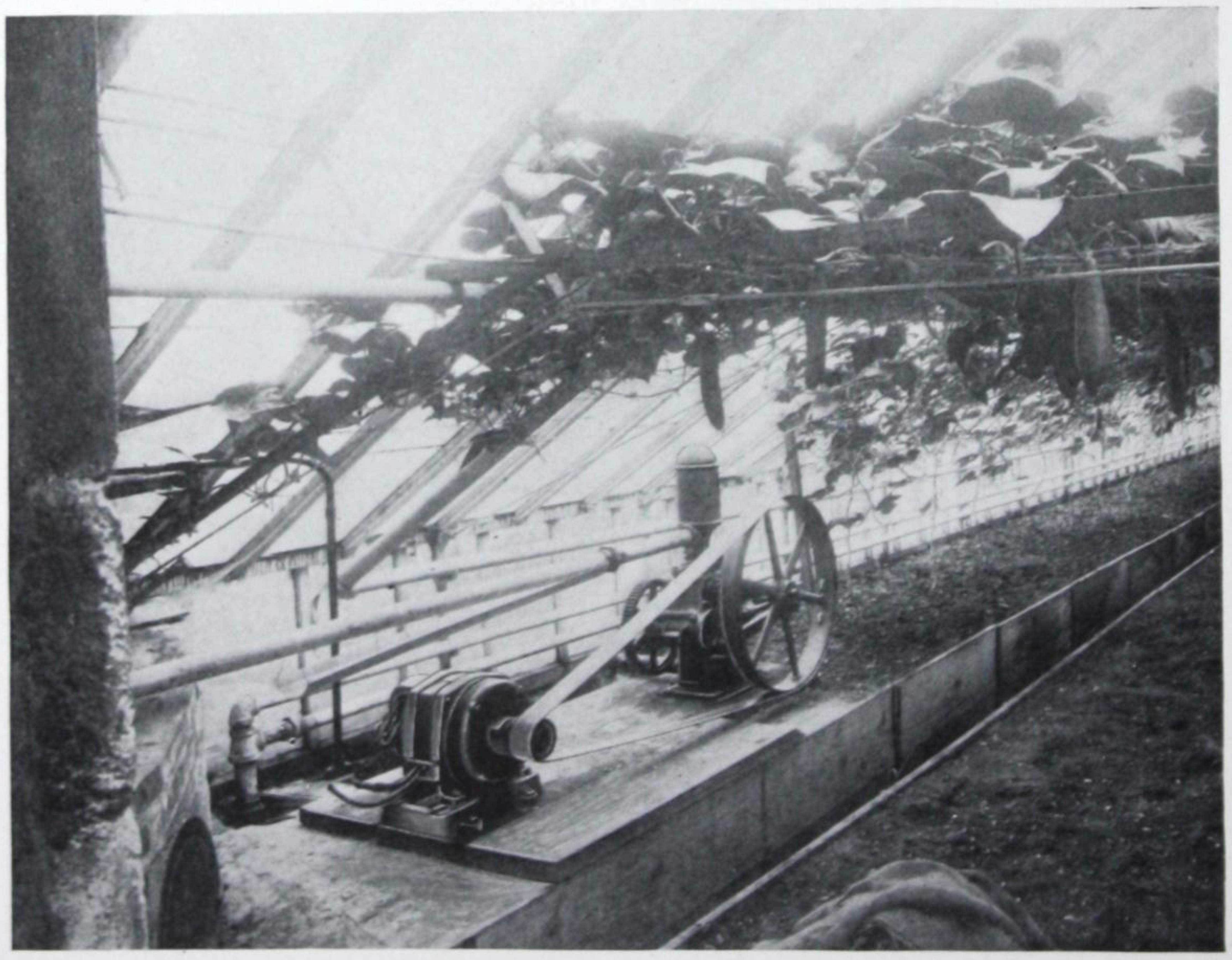
and in this way he is enabled to irrigate land which is above his source of water supply. This is impossible when the gravity system is used.

Irrigation pumping, from the farmer's point of view, has many advantages, in that a pumping plant will give him water just at the time he wants it, and this is a more important factor to him than the saving of the money effected. It is exceptional to be able to get water just at the time when it is wanted, when irrigating from a ditch, as ditch riders and water superintendents must serve all alike. Not only this; but when water is turned into a ditch, it must be run in quantities in order to secure economy, and it is not possible that every man along a ditch will be similarly situated with regard to the progress of his work so that all will require water at any one time.

If water is to be pumped, some kind of power is necessary to operate the pump. Among the more important sources of power are the gasolene engine, steam engine, and electric motor. The latter, however, is rapidly displacing the other two wherever electric power is available, just as it has already done in the city. The principal advantage of the electric motor is that its power is instantaneously available and it will always run when

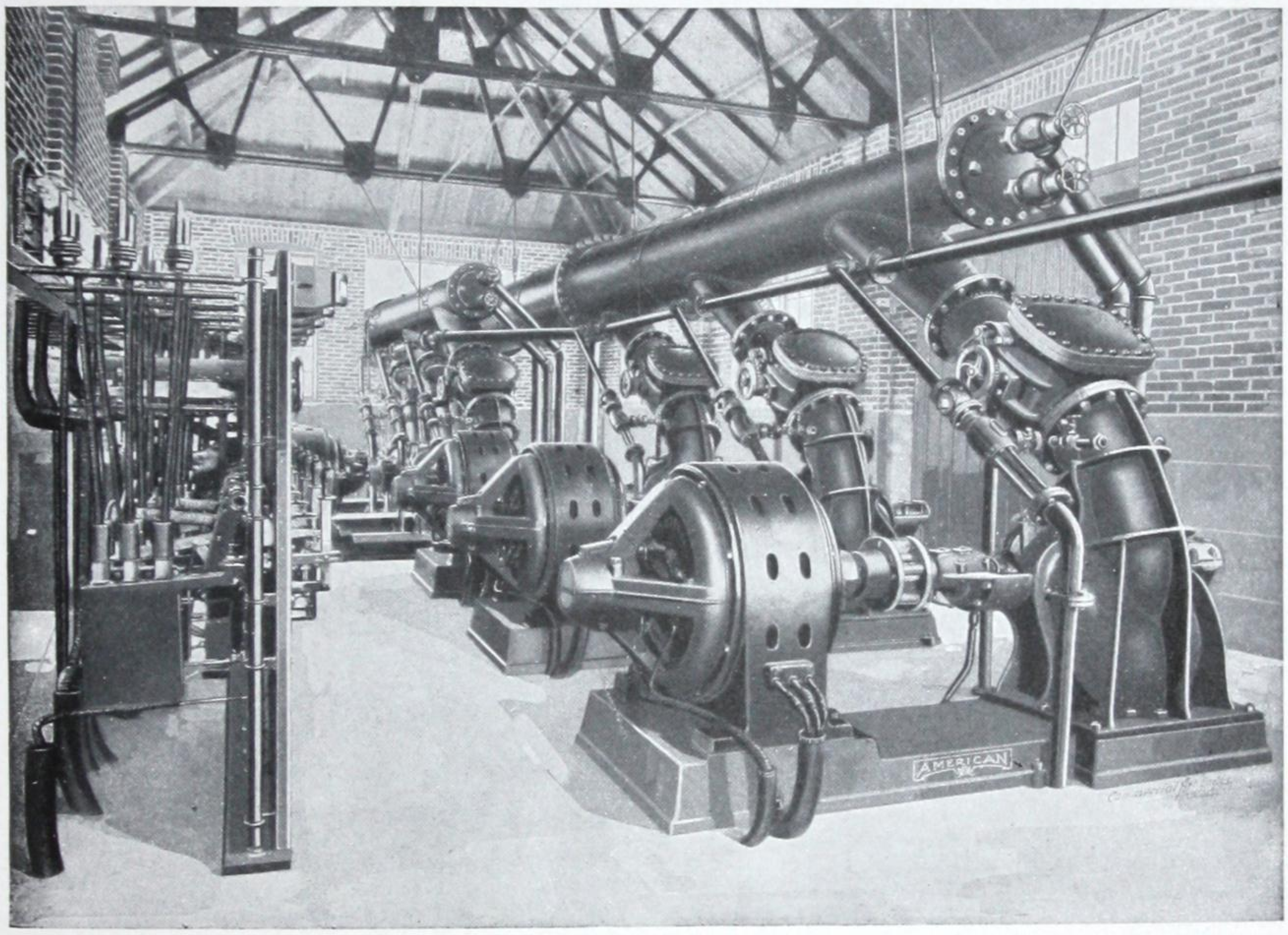


5 H.P. Induction Motor Belted to Pump. Supplies Water for 12 Large Greenhouses From a Well 600 Feet From Pump. George Titus & Company, Irondequoit, N. Y.



2 H.P. RI Motor Belted to Pump for Water Supply. Wm. Hill, Irondequoit, N. Y.

wanted. Not only this; but it can be run for months at a time without shutting down the plant, and there are thousands of electric pumping installations in the far west which run twenty-four hours a day for six months at a time; this being entirely feasible as the only attendance that is required for electrical equipment is an occasional oiling of the motor bearings. The steam engine on the other hand requires the constant attendance of a licensed engineer, while the gasolene engine has a large number of moving parts, which must necessarily be adjusted from time to time. It is practically impossible to operate a gasolene engine for six months at a time without extensive repairs at the end of the period. Being able to run the electric motor all the time is therefore a distinct advantage,



Irrigation Pumping Plant at Payette, Idaho, Showing G-E Induction Motors Direct Connected to Centrifugal Pumps

in that a small reservoir can be used to store the water pumped during the night, and in this way a much smaller equipment can be used than would otherwise be required. The electric motor has the added advantage of remote control, the farmer being able to stop and start it even if he is several miles away.

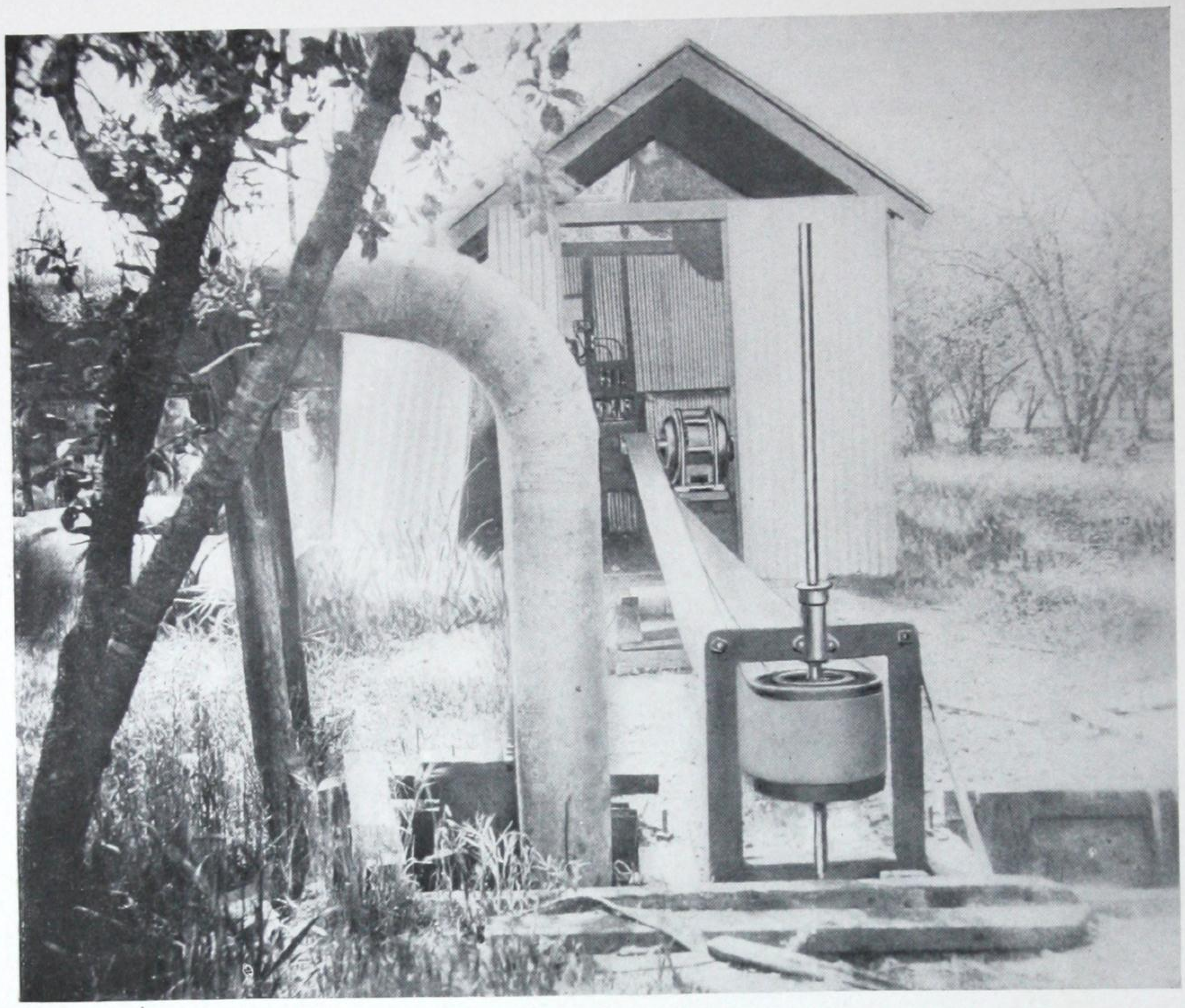
Cost of Irrigation

The cost of pumping water for irrigation is divided into four heads:

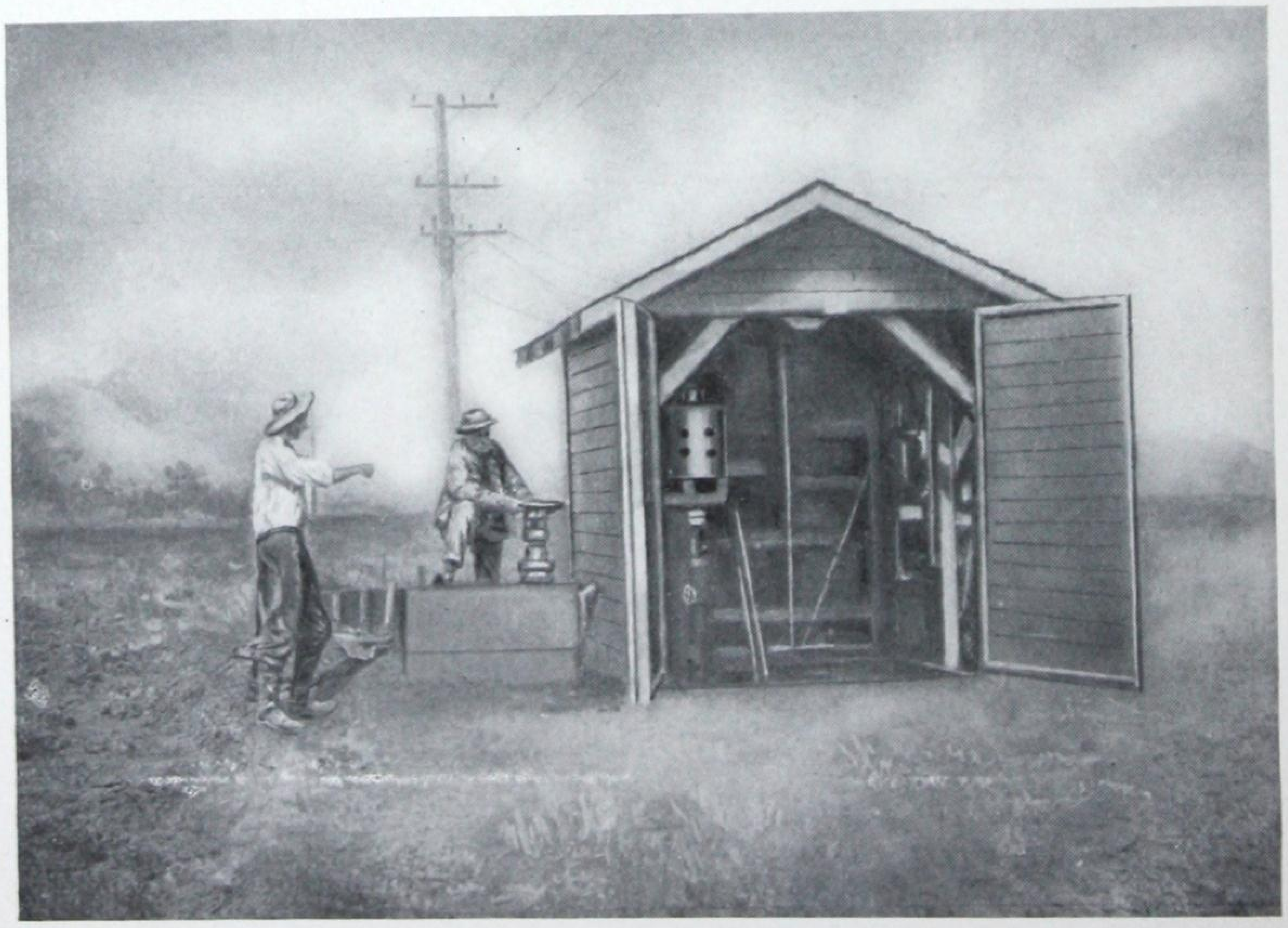
1st. Interest on investment.
2nd. Power consumption.
3rd. Repairs, labor, attention and maintenance.
4th. Depreciation (or ultimate life).

Interest on Investment

An electrically driven outfit, providing that transmission lines are anywhere in the neighborhood, never costs more, and usually costs less, than a gasolene or steam equipment



G-E Induction Motor Driving Pump Shaft Through Quarter Turn Belt



Vertical Shaft G-E Induction Motor Direct Coupled to Pump Shaft

of the same quality and capacity; and therefore the interest on the investment is never higher than that charged against the gasolene and steam plant.

Power Consumption

With the ever-increasing prices for gasolene, and the corresponding decreasing rates for electric power, the electric motor has a decided advantage in power cost.

Repairs, Labor, Attention and Maintenance

This item is always less in the case of the electric motor than with other forms of power, for the reasons already given.

Portable Motor Used for Intermittent Irrigation Pumping

Depreciation (or Ultimate Life)

Figures given by the U.S. Government (see bulletin No. 181 issued by the Office of Experiment Stations, entitled "Mechanical Tests of Pumping Plants in California"), show the depreciation on the electrical equipment to be about 7 per cent, gasolene engines about 12 to 15 per cent, and steam engines about 11 per cent; and as the gasolene and steam outfits cost more, and the depreciation is larger; this means a very considerable saving in favor of electric power.

The following tables show the comparative costs for gasolene and electric power, when irrigating both 40 and 160 acres of land.

Comparative Cost of Irrigation

Gasolene Outfit

Tract Irrigated	40 Acres
Water to be pumped in one year: 12 irrigations 2 in. deep; 10 irrigations 2.4 in. deep; 8 irrigations 3 in. deep; 6 irrigations 4 in. deep; 4 irrigations 6 in. deep	80 acre ft.
Water pumped but lost in evaporation and seepage	20 acre ft.
Total water to be pumped	100 acre ft.
100 acre feet converted into gallons (325,852 gal. = 1 acre foot)	32,585,200 gal.
Size of pump to obtain irrigation head	500 gal. per min.
Assumed distance that water is to be pumped (lift)	30 ft.
Size of engine necessary	10 h.p.
Actual engine h.p. required	8½ h.p.
Number of hours engine required to run pumping 500 gal. per min. to pump 32,585,200 gal.	1086 hours
Gasolene used per h.p. hour	⅛ gallon
Cost of gasolene per h.p. hour at 10c. per gal.	1¼c. h.p. hour
Cost of operating 8½ h.p. per hour	$0.106
Cost of operating 8½ h.p. 1086 hours	$115.10
Cost of lubricating oil for operating 8½ h.p. for 1086 hours at ¼c. per h.p. hr.	$23.05

Cost of 10 h.p. engine	$555.00	
Cost of 500 gal. pump	87.50	
Cost of belting	20.00	
Cost of fittings	10.00	
Total	$672.50	
Interest at 8 per cent on $672.50		$53.80
Depreciation on engine $555.00 at 15 per cent		83.25
Total operating cost per year		$275.20

Electric Outfit

200 gal. per min. with pump operating 24 hours per day into a reservoir will give a head of water of 500 g.p.m. for 10 hours each day for irrigation purposes, the same head as the gasolene engine, but in pumping 200 g.p.m. instead of 500 g.p.m. the water in the well will only lower to 25 feet, requiring 2.8 h.p. input to the motor to pump 200 gal. per min.

Cost of 2.8 h.p. at $50.00 per h.p. per year		$140.00
Cost of lubricating oil		2.50
Cost of 3 h.p. motor outfit including motor direct connected to pump, transformers, circuit breaker, all complete with fittings	408.00	
Cost of reservoir with oil dirt	150.00	
Total	$558.00	
Interest at 8 per cent on $558.00		44.64
Depreciation on $408.00 at 7 per cent		28.56
Total		$215.70

In favor of electricity $59.50.

NOTE.—This does not take into consideration the cost of attendance as well as the loss of time, due to breakages, etc., both of which will be considerably greater when a gasolene engine is used. It will be noticed that the price of gasolene was taken at ten cents per gallon. This was done in order to show that a saving would result, even at this low figure. The average price of gasolene is over twenty cents per gallon and the following figures show the saving per year in favor of electric power.

With Gasolene per Gallon	Electricity Makes a Saving per Year of	With Gasolene per Gallon	Electricity Makes a Saving per Year of
10c.	$59.50	18c.	$151.58
11c.	71.01	19c.	163.09
12c.	82.52	20c.	174.60
13c.	94.03	21c.	186.11
14c.	105.54	22c.	197.62
15c.	117.05	23c.	209.13
16c.	128.56	24c.	220.64
17c.	140.07	25c.	232.15

The price of electricity will also vary somewhat depending on the locality, and the local prices of fuel and electricity will have to be substituted in the table in order to determine the exact saving in favor of electric power.

At first thought, it would appear that the basis of comparison is not the same. However, the figures as given in the table of comparative costs, show changes in conditions, brought about by the use of electric power. These changes in themselves are advantages, and effect considerable saving both in installation and operating costs. For any other arrangement, or combination of conditions, the economy and advantages of electric power, are clearly apparent.

Comparative Cost of Irrigation

Tract Irrigated — Gasolene Outfit — 160 Acres

Gasolene Outfit

Water to be pumped in one year: 12 irrigations 2 in. deep / 10 irrigations 2.4 in. deep / 8 irrigations 3 in. deep / 6 irrigations 4 in. deep / 4 irrigations 6 in. deep — 320 acre feet

Water pumped but lost in seepage and evaporation		80 acre feet
Total water to be pumped in one year		400 acre feet
400 acre feet converted into gallons { 325,852 gal. / 1 acre foot }		130,340,800
Size of pump to obtain irrigation head		1600 gal. per min.
Assumed distance that water is to be pumped		30 ft.
Size of engine necessary		30 h.p.
Actual engine h.p. required		25 h.p.
No. of hours engine required to run pumping 1600 g.p.m. to pump 130,340,800 gal.		1358 hours
Gasolene used per h.p. hour		⅛ gal.
Cost of gasolene per h.p. hour at 10c. per gal.		1¼c.
Cost of operating 25 h.p. per hour		31¼c.
Cost of operating 25 h.p. 1358 hours		$424.37
Cost of lubricating oil at ¼c. per h.p. hour		85.00
Cost of 30 h.p. gasolene engine	$1000.00	
Cost of 1600 gallon pump	210.00	
Cost of belting	50.00	
Cost of fittings	40.00	
Total	$1300.00	
Interest at 8 per cent on $1300.00		104.00
Depreciation at 15 per cent on engine $1000.00		150.00
Total operating cost per year		$763.37

Electric Outfit

666 g.p.m. with pump operating 24 hours per day into a reservoir will give a head of water of 1600 g.p.m. for 10 hours each day for irrigating purposes, the same head as the gasolene engine, but in pumping 666 g.p.m. instead of 1600 g.p.m. the water will only lower in the well 25 ft. requiring 8.3 h.p. to pump 666 g.p.m.

Cost of 8.3 h.p. at $50.00 per h.p. per year		$415.00
Cost of lubricating oil		10.00
Cost of 10 h.p. outfit including motor direct connected to pump and transformer, and circuit-breaker, all complete, with fittings .	$676.00	
Cost of reservoir with oil dirt	400.00	
Total	$1076.00	
Interest at 8 per cent on $1076.00		86.08
Depreciation at 7 per cent on $676.00		47.32
Total		$558.40

In favor of electricity $204.97.

Note.—This does not take into consideration the cost of attendance as well as the loss of time, due to breakages, etc. both of which will be considerably greater when a gasolene engine is used. It will be noticed that the price of gasolene was taken at ten cents per gallon. This was done in order to show that a saving would result, even at this low figure. The average price of gasolene is over twenty cents per gallon and the following figures show the saving per year in favor of electric power.

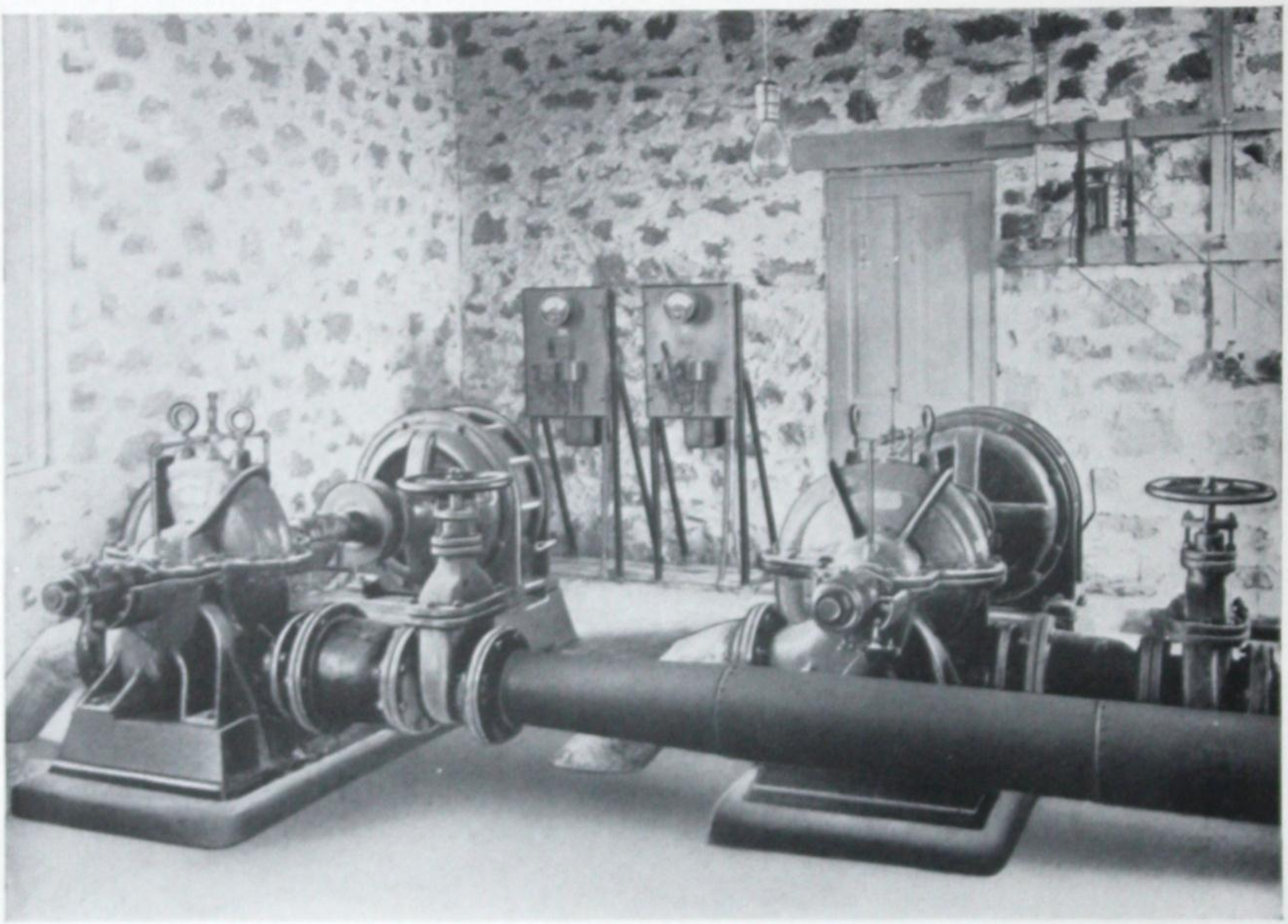
With Gasolene per Gallon	Electricity Makes a Saving per Year of	With Gasolene per Gallon	Electricity Makes a Saving per Year of
10c.	$204.97	18c.	$544.47
11c.	247.41	19c.	586.90
12c.	289.84	20c.	629.34
13c.	332.28	21c.	671.78
14c.	374.72	22c.	714.21
15c.	417.16	23c.	756.65
16c.	459.59	24c,	799.09
17c.	502.03	25c.	841.53

The price of electricity will also vary somewhat depending on the locality, and the local prices of fuel and electricity will have to be substituted in the table in order to determine the exact saving in favor of electric power.

At first thought, it would appear that the basis of comparison is not the same. However, the figures as given in the table of comparative costs, show changes in conditions, brought about by the use of electric power. These changes in themselves are advantages, and effect considerable saving both in installation and operating costs. For any other arrangement, or combination of conditions, the economy and advantages of electric power are clearly apparent.

Wells

No general recommendation can be given as to the most desirable type of well, as the depths at which water can be obtained vary greatly in different localities, and it should also be taken into consideration whether the water is desired for irrigation only, or is to be used for drinking purposes in addition to furnishing the irrigation supply. If wells are to be sunk only for irrigation purposes, there is to be considered only the depth at which a sufficient supply of water can be secured, and the kind of power that is to be used to drive the pump, as the cost of pumping is the principal element in determining the economy of the installation.

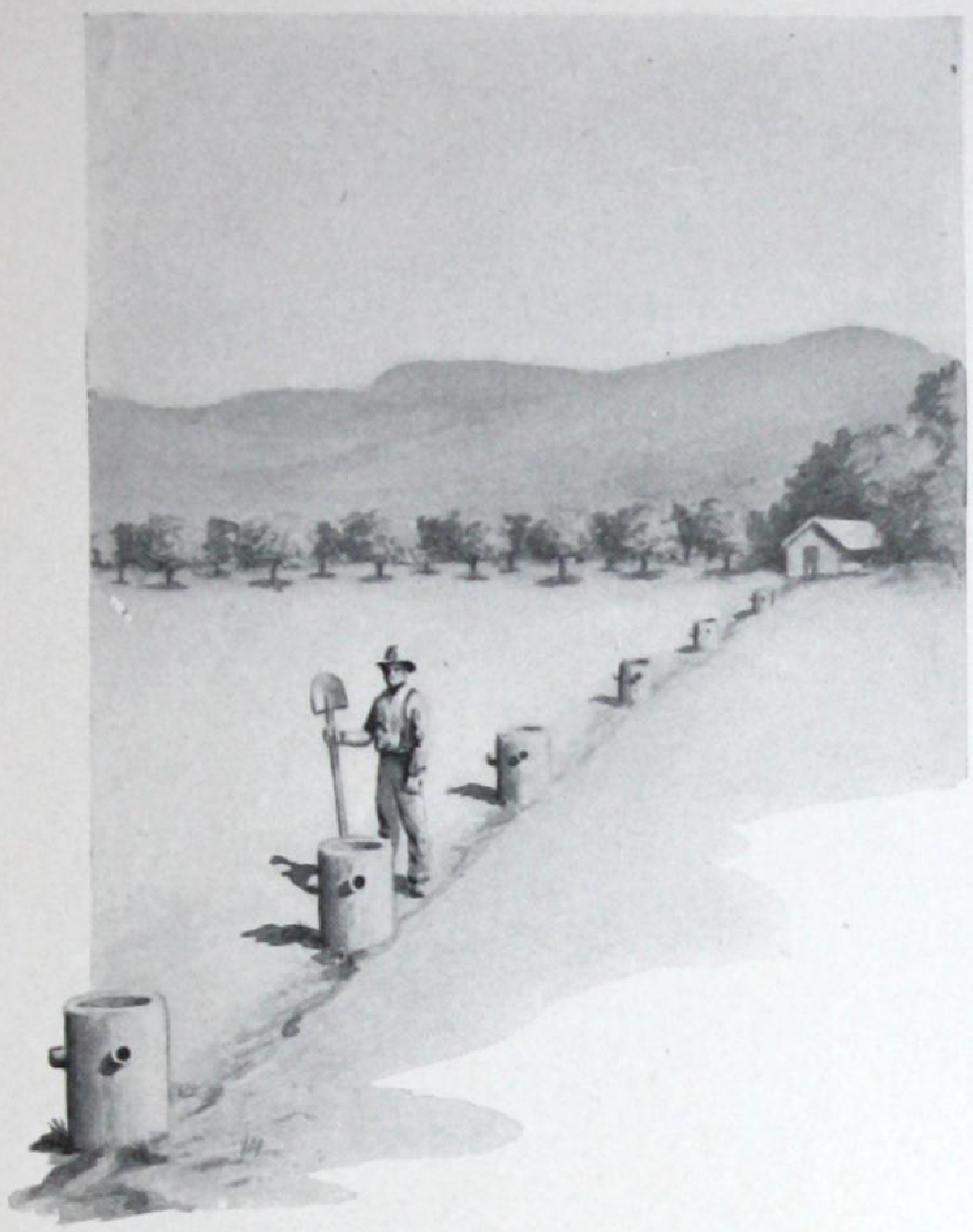


Irrigation Pumping Station at Twin Falls, Idaho, Showing 2-50 H.P. Induction Motors Direct Connected to 8 In. Centrifugal Pumps

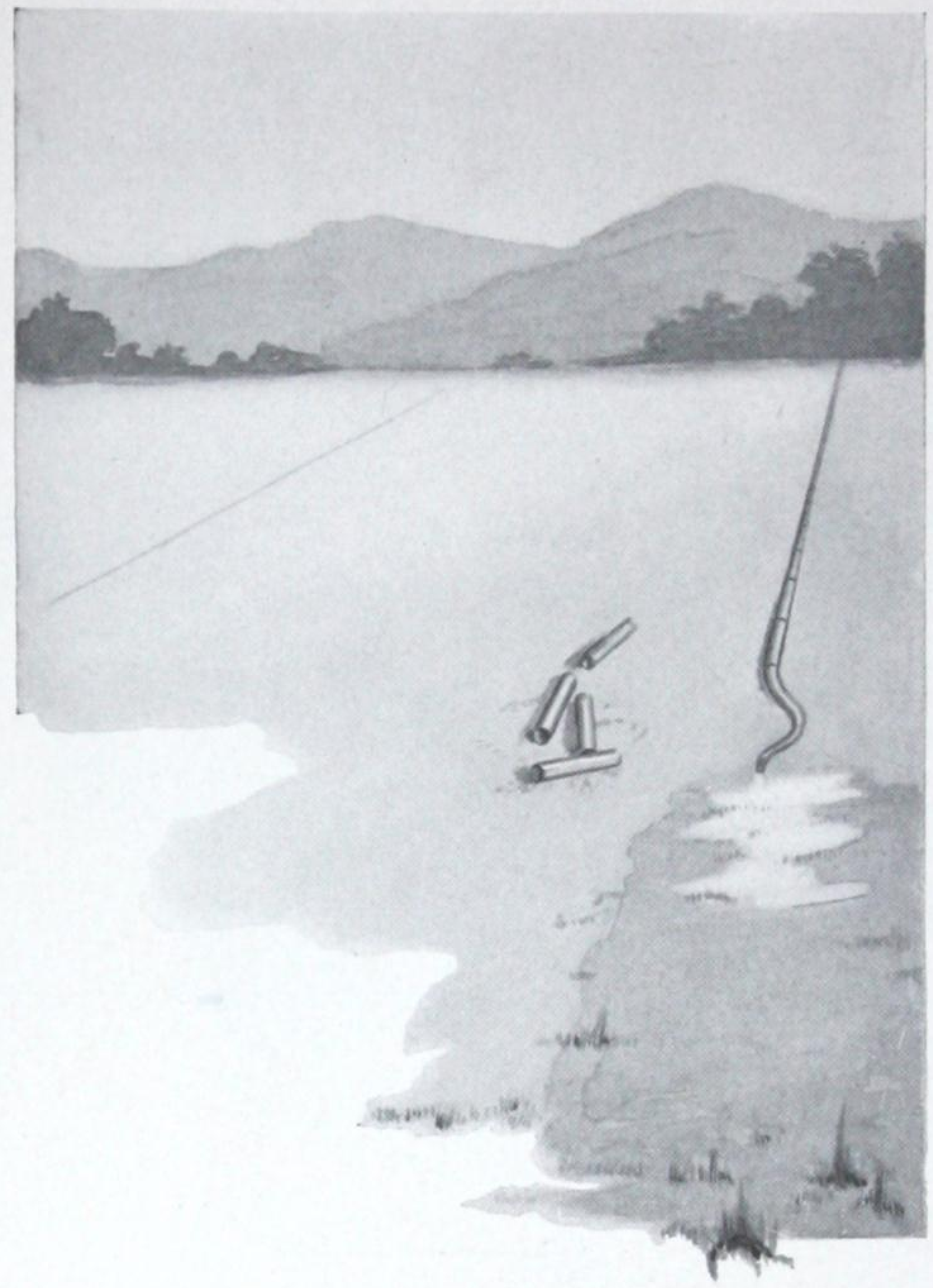
Storage Reservoirs

Water has a higher duty for irrigation, either when irrigating by furrows or by flooding, when a considerable flow is turned on a parcel of ground at one time. For this reason, when using a small size pump it is usually desirable to have a reservoir equal to the amount that the pump will furnish in eight or ten hours. If the supply of water exceeds 500 gallons per minute, it is possible to dispense with the reservoir. Where the capacity of the pumps exceeds 1000 gallons per minute, reservoirs are rarely installed.

The use of a small reservoir gives a very distinct advantage to the electric motor, as it enables a man who is irrigating, to use a smaller equipment and pump water 24 hours per day, storing the water pumped during the night in the reservoir and using it and the water pumped during the daylight hours to irrigate his land. This is practically impossible with any other form of power, as only the electric motor can be safely run the whole night long without any attention whatsoever.



The Stand-Pipe Method Showing Arrangement of the Distributing Stand-Pipes



The Slip-Joint Pipe Method

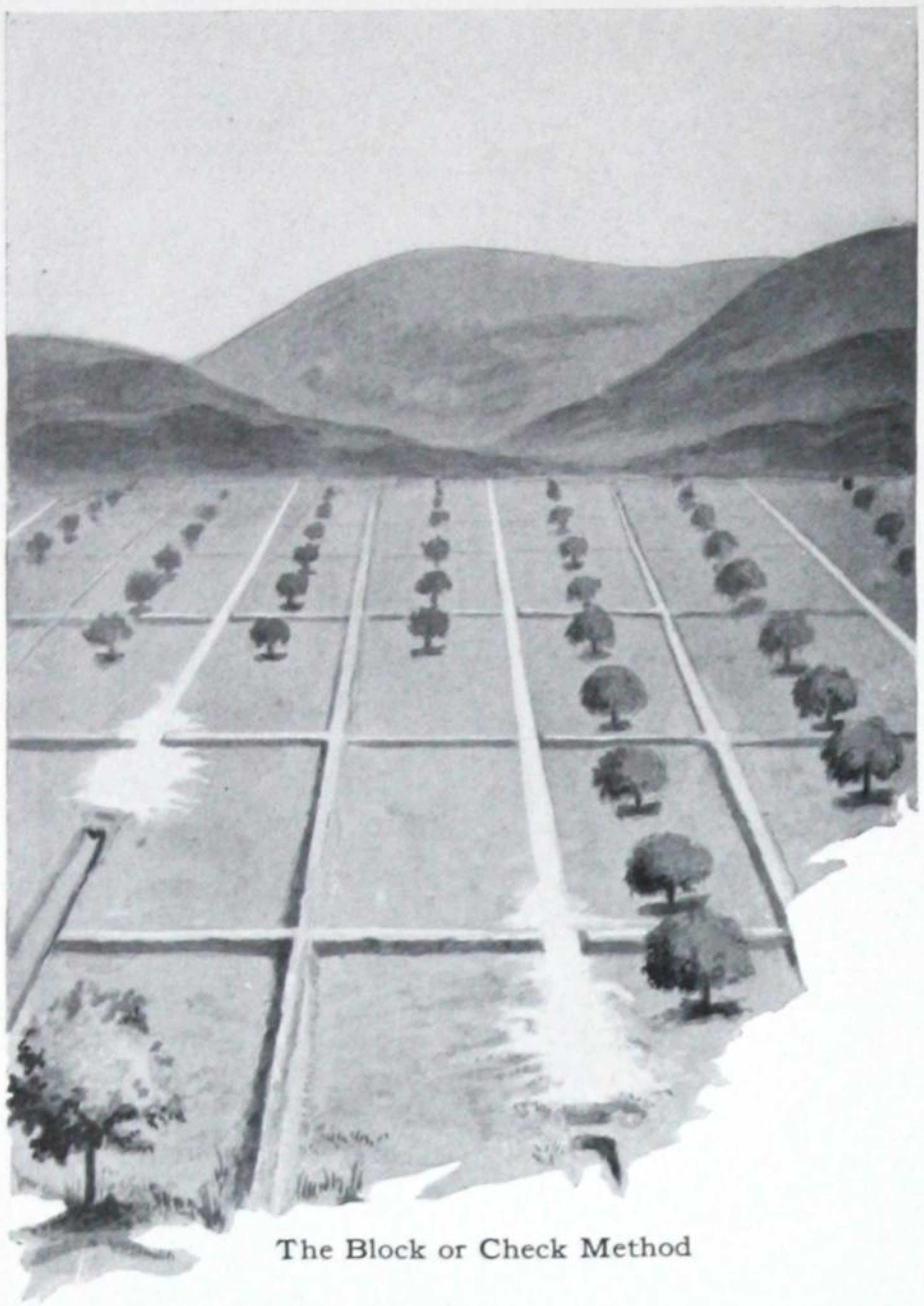
Methods of Applying Water

The most economical manner of applying water for irrigation in the United States depends on so many different conditions between the Eastern and Western states that the subject is best considered under irrigation systems adapted for arid and semi-arid regions and those for humid climates.

In the Western states, lands to be irrigated are usually leveled so that water can be applied to them by ditches or flooding. In the Eastern states, it is not practicable to level a large percentage of the land, and much of the ground irrigated at the present time is located where intensive tillage is practiced in truck raising and orchards, although water is now being applied with profit in many cases to the field crops. Therefore, the best irrigation methods of one section of the country may not be adapted to much of the land irrigated in another.

Methods of Irrigation in Arid Regions

There are six general methods of applying water to the land in the Western states, namely: The stand-pipe method, the slip-joint pipe method, the block method, the flooding method, the furrow method and the zigzag method.


The Block or Check Method


The Flooding Method

Stand-Pipe Method

The stand-pipe method consists of a series of stand pipes placed along the highest line of the field to which the water flows through an underground pipe, and is brought to the surface by these distribution stands or basins and distributed into the furrows through small galvanized iron or tile spouts inserted into the sides of the basins.

Slip-Joint Pipe Method

Where water is scarce it is sometimes applied to the crop by what is known as the "Slip-joint pipe" method. The pipe is usually made of light galvanized iron in lengths of 12 ft., it is easily moved about the field and does away with the evaporation and seepage losses common to earthen ditches. By this method the field does not require previous leveling, as only a small area is wetted at one time. A small patch near the discharge pipe is covered with water, then a section of the pipe is taken off and another small area watered and so on, across the field.

Block or Check Method

The block or check method of irrigation is used on light sandy soils and also on heavy soils where it is necessary to hold water on the land to secure its percolation to the desired depth. It is best adapted for land which has a slope of 3 to 15 ft. to the mile. The essential features consist of surrounding, when leveling, plots of ground with low levees and in making provision to flood each by means of a ditch or check box.

Flooding

The most common method of irrigation in the United States is by flooding, but this system does not give as equal a distribution of water on the land as other methods, unless

special care is taken. It is more wasteful of water and requires more manual labor, but it is still in most extensive use on account of the small cost required to level the land and to construct the necessary ditches: It could be profitably used on slopes that are too steep for other methods. Fields having a firm soil and a fall of 25 ft. in each 100 ft. have been flooded successfully. In grading land for this method of irrigation it is not customary to make many changes in the natural surface.

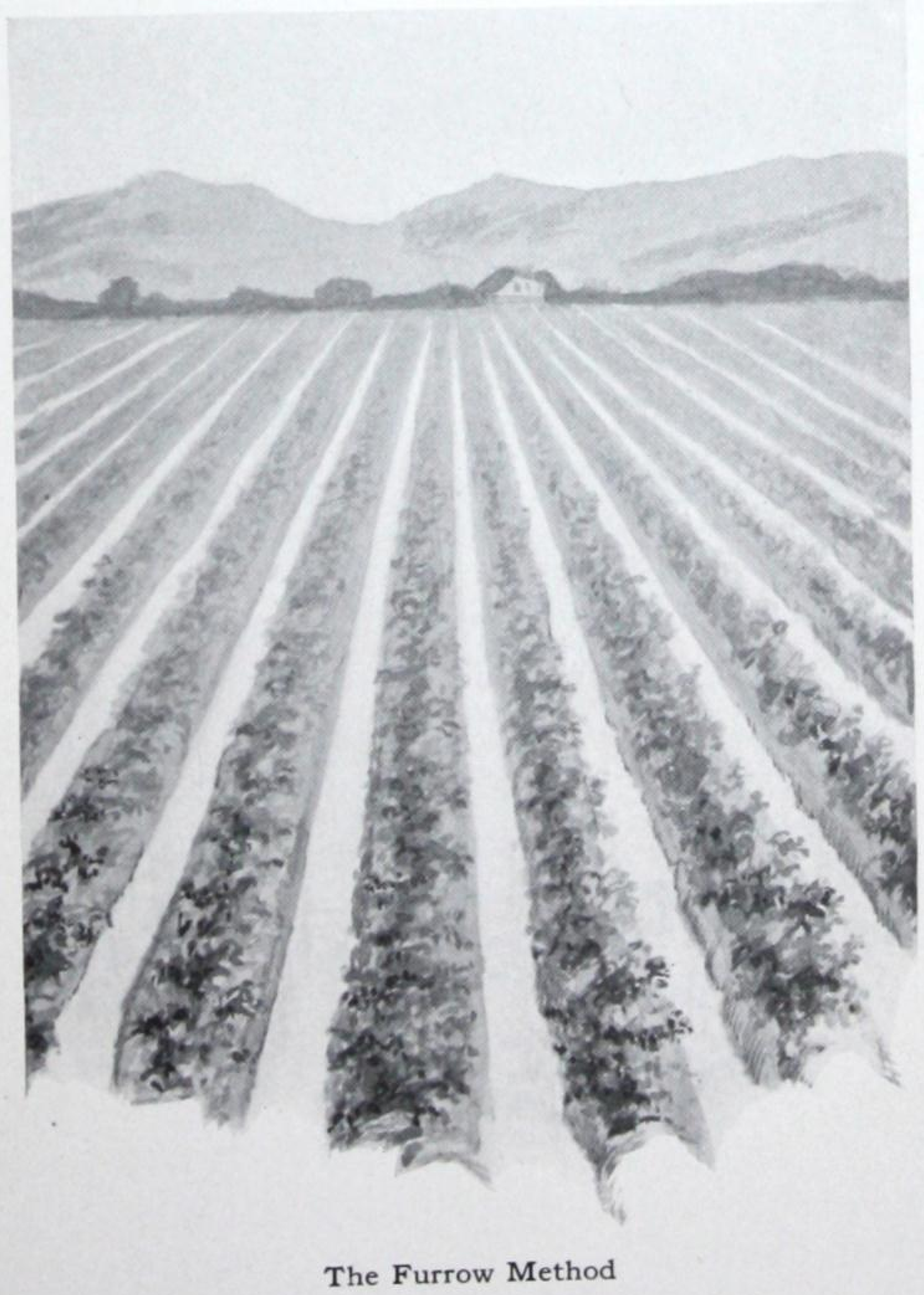
The smaller knolls are scraped off into the hollows and an effort made to make the laterals fit into the natural slope and configuration of the tract to be watered, so as to bring the water to the highest point. The head required for flooding field laterals usually varies from 2 to 3 cu. ft. per second and is divided between 2 or 3 laterals. Canvas or coarse manure dams are used to check the water in the laterals and to force it out over the banks and down the slopes of the field.

Furrow

Irrigation by furrows has the advantage as compared with flooding, in that, where land is covered with water it has a tendency to bake and crack, and when a small volume is permitted to flow in the bottom of the narrow ditch for several hours, the soil beneath and for some distance on either side becomes wet while the surface remains nearly dry. The common practice for irrigating by this method is to run the furrows the entire width and length of the field. The furrows are often made too long. As a rule they should not exceed 660 ft. for fine close soil and not over 250 ft. for coarse gravelly soil.

Zigzag

The zigzag method is generally limited to use in old orchards where it is not practicable to make parallel furrows sufficiently close to the trees to irrigate them properly.

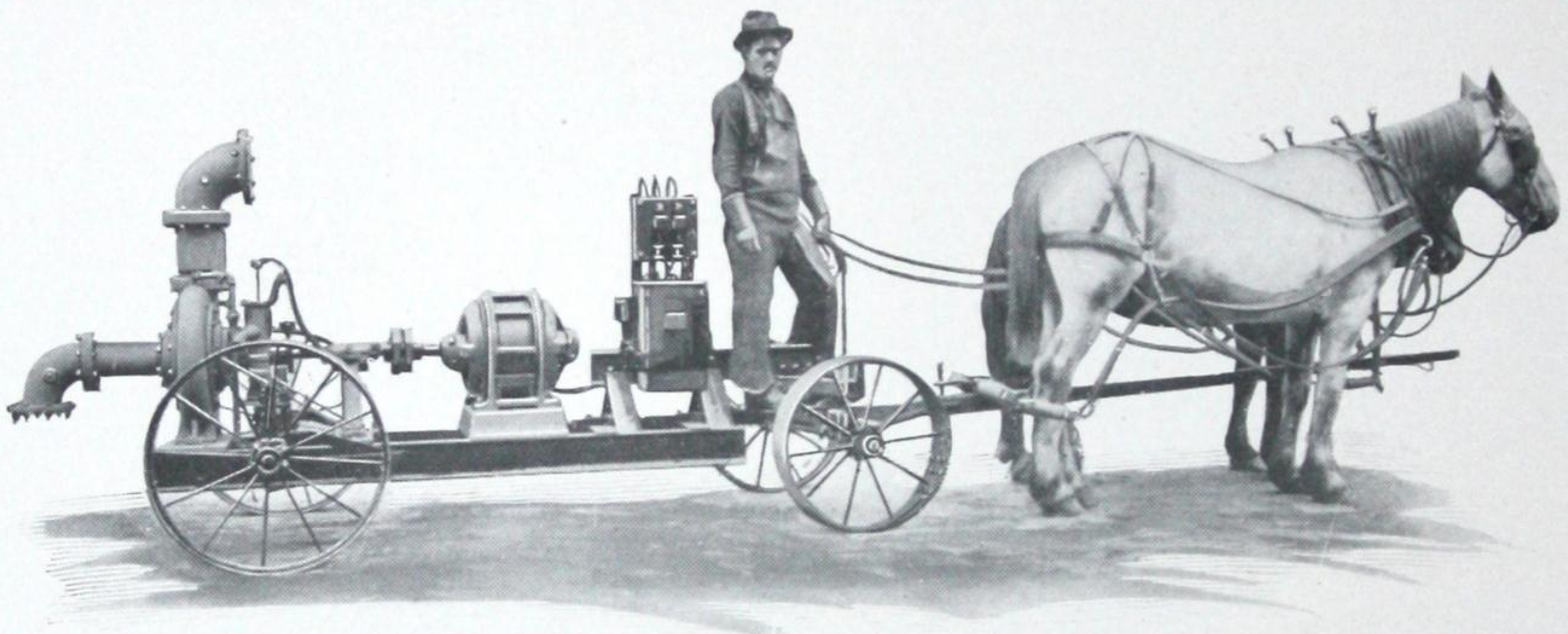


The Furrow Method

Methods of Irrigation in the Humid Regions

Surface irrigation is most commonly used in the Western states, but cannot be so readily adapted in the humid regions, as it is often impracticable to change regular shaped fields and long rows to irregular ones conforming to the topography of the land.

It is impossible to grade land having a shallow soil, without destroying the productiveness of a large part of the surface. Many areas in the humid regions are adapted for sub-surface irrigation through an under ground tile or pipe. Sub-irrigation requires level land having a shallow porous surface soil overlying an impervious sub-stratum. Only shallow rooted crops can be grown without danger of stopping up the tile. Sub-irrigation is not usually in practice, except for crops that will pay interest on a system costing $100.00 or more per acre. The system which has the greatest possibilities for irrigation in humid regions distributes the water through the fields under pressure, spraying it into the air and letting the moisture drop like gentle rain. This method is sometimes known as the aerial method or the Skinner system, and will distribute water evenly



Portable Electric Motor-Driven Pumping Outfit for Irrigation and Drainage

over the surface of rough or rolling ground regardless of soil or underground conditions. The spray system is especially adapted to conditions in the humid sections as the demand is usually for small and frequent applications of water.

The Duty of Water

The quantity of water needed for irrigation depends on the nature of the soil, the kind of crop, the amount of humidity, the rainfall, the temperature and the state of growth. All plants require the most water at the period of greatest growth. With the quantity of water required varying so much in different localities due to the above conditions, it is impossible to state definitely the amount of water required to irrigate various crops, as no such general information exists. However, any one who is thinking of installing an irrigation plant should consult his State Agricultural Experiment Station in this matter, as these stations have made a special study of local conditions and know how much water is needed in a given locality.

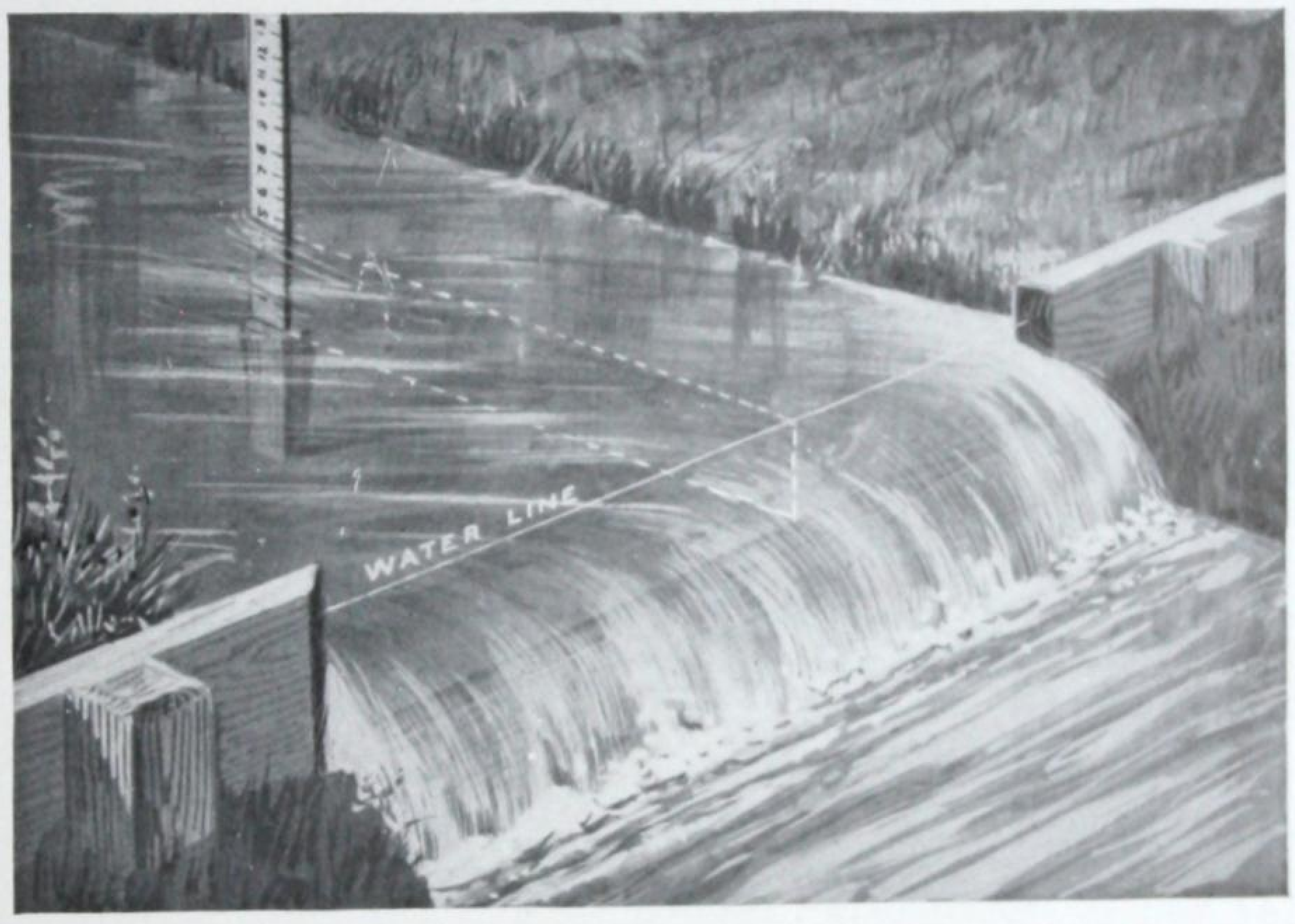
How to Measure Your Water Supply

It is advisable in pumping water for irrigation from wells, to measure the quantity of water the well or wells are producing, and only to attempt to irrigate one hundred acres for each five to seven hundred gallons of water produced per minute.

The reason for referring to this matter is that a large percentage of irrigation wells are over-estimated as to their capacity. Hence there is frequently a great shortage of water, due to the fact that the amount of water the wells are actually producing is not known.

How to Make a Weir

Place a notched board or plank in the stream at some point where a pond will form above it. The length of the notch in the plank should be from two to four times its depth where small quantities of water are to be measured and four to eight times the depth where large quantities are to be measured. The edges of the notch should be beveled as shown in sketch with the slant down stream. The distance between the bottom of the notch and the level of the water in the pool below the dam should not be less than twice the depth of the notch. Drive a stake in the pond about six feet



Weir for Measuring Flow of Water

above the dam with its top precisely level with the lower edge of the notch, then complete the dam so that all the water will flow through the notch. The depth of the water flowing through can easily be measured by means of a rule placed on top of the stake as shown in the sketch.

It is essential, in building a weir, that the bottom of the notch should be as nearly level as possible, and that the water be backed up in the stream far enough so that it will approach the weir very slowly.

Example

The illustration given above is that of a two ft. weir (notch), with water flowing over it as shown by the rule to a depth of four and one-half inches. By referring to the weir table on page 54 under the title "2 ft. Weir with Full Contractions," in the left-hand column we find four inches. Now read across this line to the column which has one-half inch at the top, and at the junction of the two is 663.17. This means that a stream of water flowing over a two foot weir and measuring four and one-half inches deep over the top of the stake equals a flow of 663.17 gallons per minute.

All measurements of this kind should be made at a point at least as far back from the crest of the weir as the width of the notch and are based on zero velocity of the water.

TABLE No. 1—SHOWING THE ACRES COVERED TO VARIOUS DEPTHS IN 1, 10, 16 AND 24 HOURS

Gallons per Minute	Gallons per Hour	Cu. Ft. Sec.	ACRES IRRIGATED IN ONE HOUR							ACRES IRRIGATED IN 10 HOURS						
			½ In. Deep	1 In Deep	2 In. Deep	3 In. Deep	4 In. Deep	6 In. Deep	8 In. Deep	½ In. Deep	1 In. Deep	2 In. Deep	3 In. Deep	4 In. Deep	6 In. Deep	8 In. Deep
1	60	0.002	0.0044	0.0022	0.0011	0.0007	0.00055	0.00037	0.00028	0.004	0.022	0.011	0.007	0.0055	0.0037	0.0028
2.5	150	0.006	0.011	0.0055	0.0027	0.0017	0.00137	0.00092	0.0007	0.11	0.055	0.0275	0.0175	0.0137	0.0092	0.007
5	300	0.011	0.022	0.0110	0.0055	0.003	0.00274	0.00184	0.0014	0.22	0.11	0.055	0.0350	0.0274	0.0184	0.014
10	600	0.022	0.044	0.0221	0.011	0.007	0.0055	0.0037	0.0028	0.44	0.22	0.11	0.07	0.055	0.037	0.028
15	900	0.033	0.066	0.0331	0.0165	0.0105	0.0082	0.0055	0.0042	0.66	0.33	0.165	0.105	0.0825	0.0555	0.0042
20	1200	0.044	0.088	0.0442	0.022	0.0148	0.011	0.0074	0.00554	0.88	0.443	0.22	0.148	0.11	0.074	0.0554
25	1500	0.056	0.11	0.0552	0.0275	0.0183	0.0137	0.0092	0.0069	1.1	0.552	0.275	0.183	0.137	0.092	0.069
30	1800	0.067	0.132	0.0663	0.033	0.0218	0.0165	0.0111	0.0083	1.32	0.663	0.33	0.218	0.165	0.111	0.083
35	2100	0.078	0.154	0.0773	0.0385	0.0253	0.0192	0.0129	0.0097	1.54	0.773	0.385	0.253	0.192	0.129	0.097
40	2400	0.089	0.176	0.0884	0.044	0.0288	0.022	0.0148	0.011	1.76	0.884	0.44	0.288	0.22	0.148	0.11
45	2700	0.100	0.198	0.0994	0.0495	0.0323	0.0247	0.0166	0.0125	1.98	0.994	0.495	0.323	0.247	0.166	0.125
50	3000	0.111	0.22	0.1105	0.055	0.0358	0.0274	0.0184	0.014	2.2	1.1	0.55	0.358	0.274	0.184	0.14
60	3600	0.133	0.264	0.1326	0.066	0.0432	0.0329	0.0221	0.0167	2.64	1.33	0.66	0.432	0.329	0.221	0.167
70	4200	0.156	0.308	0.1547	0.077	0.0506	0.0384	0.0258	0.0195	3.08	1.55	0.77	0.506	0.384	0.258	0.195
80	4800	0.178	0.352	0.1768	0.088	0.058	0.0439	0.0295	0.0224	3.52	1.77	0.88	0.58	0.439	0.295	0.224
90	5400	0.200	0.396	0.1989	0.099	0.0654	0.0494	0.0332	0.0252	3.96	1.99	0.99	0.65	0.494	0.332	0.252
100	6000	0.222	0.44	0.221	0.11	0.0736	0.055	0.0369	0.028	4.4	2.21	1.1	0.73	0.55	0.369	0.28
125	7500	0.278	0.55	0.276	0.137	0.0919	0.0687	0.0461	0.0349	5.5	2.76	1.37	0.92	0.687	0.461	0.349
150	9000	0.334	0.66	0.331	0.165	0.11	0.0824	0.0553	0.0418	6.6	3.31	1.65	1.1	0.824	0.553	0.418
175	10500	0.389	0.77	0.3866	0.182	0.1285	0.0961	0.0645	0.0487	7.7	3.86	1.8	1.28	0.961	0.645	0.487
200	12000	0.445	0.88	0.442	0.22	0.148	0.11	0.074	0.0554	8.8	4.42	2.2	1.48	1.1	0.74	0.554
250	15000	0.556	1.1	0.552	0.275	0.183	0.137	0.092	0.069	11.0	5.52	2.75	1.83	1.37	0.92	0.69
300	18000	0.667	1.32	0.663	0.33	0.218	0.165	0.111	0.083	13.2	6.63	3.3	2.18	1.65	1.11	0.83
350	21000	0.778	1.54	0.773	0.385	0.253	0.192	0.129	0.097	15.4	7.73	3.85	2.53	1.92	1.29	0.97
400	24000	0.889	1.76	0.884	0.44	0.288	0.220	0.148	0.110	17.6	8.84	4.40	2.88	2.20	1.48	1.10
450	27000	1.000	1.98	0.994	0.495	0.323	0.247	0.166	0.125	19.8	9.94	4.95	3.23	2.47	1.66	1.25
500	30000	1.110	2.2	1.105	0.55	0.358	0.274	0.184	0.140	22.0	11.00	5.50	3.58	2.74	1.84	1.40
600	36000	1.330	2.64	1.326	0.66	0.432	0.329	0.221	0.167	26.4	13.30	6.60	4.32	3.29	2.21	1.67
700	42000	1.560	3.08	1.547	0.77	0.506	0.384	0.258	0.195	30.8	15.50	7.70	5.06	3.84	2.58	1.95
800	48000	1.780	3.52	1.768	0.88	0.580	0.439	0.295	0.224	35.2	17.70	8.80	5.88	4.39	2.95	2.24
900	54000	2.000	3.96	1.990	0.99	0.654	0.494	0.332	0.252	39.6	19.90	9.90	6.50	4.94	3.20	2.25
1000	60000	2.220	4.4	2.21	1.10	0.736	0.550	0.369	0.280	44.0	22.10	11.00	7.30	5.50	3.69	2.80
1100	66000	2.440	4.85	2.43	1.21	0.810	0.605	0.406	0.308	48.4	24.30	12.10	8.10	6.05	4.06	3.80
1200	72000	2.670	5.28	2.65	1.32	0.885	0.660	0.443	0.336	52.8	26.50	13.20	8.85	6.60	4.43	3.36
1300	78000	2.890	5.72	2.78	1.43	0.958	0.715	0.480	0.364	57.2	28.70	14.30	9.58	7.15	4.80	3.64
1400	84000	3.110	6.16	3.09	1.54	1.03	0.770	0.517	0.392	61.6	30.9	15.40	10.30	7.70	5.17	3.92
1500	90000	3.340	6.00	3.32	1.65	1.10	0.824	0.554	0.420	66.0	33.2	16.50	11.00	8.24	5.54	4.20
1600	96000	3.560	7.04	3.54	1.76	1.18	0.879	0.590	0.448	70.4	35.4	17.60	11.80	8.79	5.90	4.47
1700	102000	3.780	7.48	3.76	1.87	1.25	0.935	0.627	0.476	74.8	37.6	18.70	12.50	9.35	6.27	4.76
1800	108000	4.000	7.92	3.98	1.98	1.33	0.990	0.665	0.504	79.2	39.8	19.80	13.30	9.90	6.65	5.04
1900	114000	4.220	8.35	4.20	2.09	1.40	1.05	0.701	0.531	83.5	42.0	20.90	14.00	10.50	7.10	5.31
2000	120000	4.450	8.80	4.42	2.20	1.47	1.10	0.738	0.560	88.0	44.2	22.00	14.70	11.00	7.38	5.60
2500	150000	5.560	11.00	5.52	2.75	1.84	1.37	0.922	0.700	110.0	55.2	27.50	18.4	13.70	9.22	7.00
3000	180000	6.670	13.20	6.62	3.30	2.21	1.65	1.110	0.840	132.0	66.2	33.00	22.1	16.50	11.10	8.40
3500	210000	7.780	15.40	7.74	3.85	2.58	1.92	1.290	0.980	154.0	77.4	38.50	25.8	19.20	12.90	9.80
4000	240000	8.890	17.60	8.85	4.40	2.95	2.20	1.490	1.120	176.0	88.5	44.00	29.5	22.00	14.70	11.02
4500	270000	10.000	19.80	9.95	4.95	3.32	2.47	1.660	1.260	198.0	99.5	49.50	33.2	24.70	16.60	12.60
5000	300000	11.100	22.00	11.00	5.50	3.68	2.75	1.840	1.400	220.0	110.0	55.00	36.8	27.50	18.40	14.00
6000	360000	13.300	26.40	13.26	6.60	4.32	3.29	2.210	1.670	264.0	133.0	66.00	43.2	32.90	22.10	16.70
7000	420000	15.600	30.80	15.47	7.70	5.06	3.84	2.580	1.950	308.0	155.0	77.00	50.6	38.40	25.80	19.50
8000	480000	17.800	35.20	17.68	8.80	5.80	4.39	2.950	2.240	352.0	177.0	88.00	58.0	43.90	29.50	22.40
9000	540000	20.000	39.60	19.90	9.90	6.54	4.94	3.320	2.520	396.0	199.0	99.00	65.4	49.40	33.20	25.20
10000	600000	22.200	44.00	22.10	11.00	7.36	5.50	3.690	2.800	440.0	221.0	110.00	73.6	55.00	36.90	28.00
15000	900000	33.400	66.00	33.20	16.50	11.00	8.24	5.540	4.200	660.0	332.0	165.00	110.0	82.40	55.40	42.00
20000	1200000	44.500	88.00	44.20	22.00	14.70	11.00	7.380	5.600	880.0	442.0	220.00	147.0	110.00	73.80	56.00

TABLE No. 1—SHOWING THE ACRES COVERED TO VARIOUS DEPTHS IN 1, 10, 16 AND 24 HOURS—(Continued)

Gallons per Minute	Gallons per Hour	Cu. Ft. Sec.	Acres Irrigated in 16 Hours							Acres Irrigated in 24 Hours						
			½ In. Deep	1 In. Deep	2 In. Deep	3 In. Deep	4 In. Deep	6 In. Deep	8 In. Deep	½ In. Deep	1 In. Deep	2 In. Deep	3 In. Deep	4 In. Deep	6 In. Deep	8 In. Deep
1	60	0.002	0.07	0.035	0.0176	0.0112	0.0088	0.0059	0.00448	0.105	0.053	0.0264	0.0168	0.0132	0.0089	0.0067
2.5	150	0.006	0.176	0.088	0.044	0.028	0.022	0.0148	0.0112	0.263	0.132	0.066	0.042	0.033	0.0221	0.0168
5	300	0.011	0.352	0.176	0.088	0.056	0.044	0.0296	0.0224	0.536	0.264	0.132	0.084	0.066	0.0444	0.0336
10	600	0.022	0.7	0.352	0.176	0.112	0.088	0.059	0.0448	1.05	0.530	0.264	0.168	0.132	0.089	0.067
15	900	0.033	1.05	0.528	0.264	0.168	0.132	0.0885	0.0675	1.58	0.795	0.386	0.252	0.198	0.133	0.101
20	1200	0.044	1.41	0.708	0.352	0.236	0.176	0.118	0.0885	2.10	1.06	0.528	0.355	0.264	0.178	0.134
25	1500	0.056	1.76	0.9	0.44	0.293	0.219	0.147	0.11	2.64	1.32	0.66	0.439	0.328	0.221	0.166
30	1800	0.067	2.1	1.06	0.528	0.349	0.264	0.178	0.133	3.17	1.59	0.79	0.523	0.396	0.266	0.199
35	2100	0.078	2.46	1.23	0.615	0.405	0.308	0.206	0.155	3.70	1.85	0.924	0.607	0.460	0.310	0.233
40	2400	0.089	2.82	1.41	0.705	0.46	0.352	0.237	0.176	4.23	2.12	1.06	0.690	0.528	0.355	0.264
45	2700	0.100	3.17	1.59	0.792	0.517	0.396	0.266	0.200	4.75	2.38	1.19	0.775	0.593	0.398	0.300
50	3000	0.111	3.52	1.77	0.88	0.573	0.438	0.294	0.224	5.28	2.64	1.32	0.860	0.657	0.442	0.336
60	3600	0.133	4.23	2.12	1.06	0.69	0.526	0.354	0.267	6.34	3.19	1.58	1.03	0.790	0.530	0.400
70	4200	0.156	4.93	2.47	1.23	0.81	0.615	0.413	0.312	7.40	3.72	1.85	1.21	0.920	0.620	0.468
80	4800	0.178	5.64	2.82	1.41	0.928	0.764	0.472	0.358	8.45	4.25	2.11	1.39	1.05	0.708	0.538
90	5400	0.200	6.35	3.19	1.58	1.04	0.79	0.531	0.403	9.50	4.78	2.37	1.56	1.19	0.796	0.605
100	6000	0.222	7.05	3.54	1.76	1.18	0.88	0.59	0.448	10.55	5.3	2.64	1.75	1.32	0.885	0.671
125	7500	0.278	8.8	4.41	2.19	1.47	1.1	0.738	0.558	13.2	6.62	3.28	2.21	1.65	1.11	0.837
150	9000	0.334	9.57	5.3	2.64	1.76	1.31	0.885	0.67	15.85	7.95	3.96	2.64	1.98	1.33	1.000
175	10500	0.389	12.3	6.19	2.91	2.05	1.54	1.03	0.782	18.5	9.25	4.32	3.07	2.31	1.55	1.17
200	12000	0.445	14.1	7.08	3.52	2.36	1.76	1.18	0.885	21.1	10.6	5.28	3.55	2.64	1.78	1.34
250	15000	0.556	17.6	9.0	4.4	2.93	2.19	1.47	1.1	26.4	13.2	6.60	4.39	3.28	2.21	1.66
300	18000	0.667	21.1	10.6	5.28	3.49	2.64	1.78	1.33	31.7	15.9	7.90	5.23	3.93	2.66	1.99
350	21000	0.778	24.6	12.3	6.15	4.05	3.07	2.06	1.55	37.0	18.5	9.24	6.07	4.60	3.10	2.33
400	24000	0.889	28.2	14.1	7.05	4.60	3.52	2.37	1.76	42.3	21.2	10.60	6.90	5.28	3.55	2.64
450	27000	1.000	31.7	15.9	7.92	5.17	3.96	2.66	2.00	47.5	23.8	11.90	7.75	5.93	3.98	3.00
500	30000	1.110	35.2	17.7	8.80	5.73	4.38	2.94	2.24	52.8	26.4	13.20	8.60	6.57	4.42	3.36
600	36000	1.330	42.3	21.2	10.60	6.90	5.26	3.54	2.67	63.4	31.9	15.80	10.30	7.90	5.30	4.00
700	42000	1.560	49.3	24.7	12.33	8.10	6.15	4.13	3.12	74.0	37.2	18.50	12.10	9.20	6.20	4.68
800	48000	1.780	56.4	28.2	14.10	9.28	7.04	4.72	3.58	84.5	42.5	21.10	13.90	10.50	7.08	5.38
900	54000	2.000	63.5	31.9	15.80	10.40	7.90	5.31	4.03	95.0	47.8	23.70	15.60	11.90	7.96	6.05
1000	60000	2.220	70.5	35.4	17.60	11.80	8.80	5.90	4.48	105.5	53.0	26.40	17.50	13.20	8.85	6.71
1100	66000	2.440	77.5	38.9	19.40	13.00	9.70	6.50	4.94	116.0	58.3	29.20	19.30	14.50	9.74	7.38
1200	72000	2.670	84.5	42.4	21.20	14.15	10.50	7.10	5.38	126.8	63.6	31.70	21.00	15.80	10.60	8.05
1300	78000	2.890	91.6	46.0	22.90	15.35	11.40	7.67	5.82	137.1	68.9	34.30	22.80	17.10	11.50	8.72
1400	84000	3.110	98.6	49.5	24.60	16.50	12.30	8.26	6.28	147.8	74.2	36.90	24.50	18.50	12.40	9.40
1500	90000	3.340	105.8	53.1	26.40	17.70	13.20	8.85	6.72	158.2	79.5	39.60	26.20	19.80	13.30	10.00
1600	96000	3.560	112.9	56.7	28.20	18.90	14.10	9.45	7.17	168.9	84.8	42.20	28.00	21.10	14.20	10.70
1700	102000	3.780	119.9	60.2	29.90	20.10	14.50	10.00	7.62	179.3	90.0	44.80	29.80	22.40	15.00	11.40
1800	108000	4.000	126.9	63.7	31.70	21.20	15.80	10.60	8.06	189.9	95.4	47.50	31.50	23.80	15.90	12.10
1900	114000	4.220	134.0	67.2	33.40	22.40	16.70	11.20	8.51	200.5	100.5	50.50	33.20	25.10	16.80	12.70
2000	120000	4.450	141.0	70.8	35.20	23.60	17.60	11.80	8.96	211.0	106.0	52.80	35.00	26.40	17.70	13.40
2500	150000	5.560	176.2	88.5	44.00	29.50	22.00	14.70	11.20	264.0	133.0	66.00	43.70	33.00	22.10	16.80
3000	180000	6.670	211.5	106.1	52.80	35.40	26.40	17.70	13.40	316.5	159.0	79.20	52.50	39.60	26.60	20.10
3500	210000	7.780	246.5	123.9	61.60	41.30	30.80	20.70	15.70	369.0	185.5	92.40	61.20	46.20	31.00	23.40
4000	240000	8.890	282.0	141.5	70.40	47.20	35.20	23.60	17.90	422.0	212.0	105.50	70.00	52.80	35.40	26.80
4500	270000	10.000	317.0	159.2	79.20	53.10	39.60	26.60	20.20	475.0	238.5	118.80	78.80	59.40	39.80	30.20
5000	300000	11.100	352.1	177.0	88.00	59.00	44.00	29.50	22.4	527.0	265.0	132.00	87.50	66.00	44.30	33.50
6000	360000	13.300	423.0	212.0	106.00	69.00	52.60	35.40	26.7	634.0	319.0	158.00	103.00	79.00	53.00	40.00
7000	420000	15.600	493.0	247.0	123.00	81.00	61.50	41.30	31.2	740.0	372.0	185.00	121.00	92.00	62.00	46.80
8000	480000	17.800	564.0	282.0	141.00	93.00	70.40	47.20	35.8	845.0	425.0	211.00	139.00	105.00	70.80	53.80
9000	540000	20.000	635.0	319.0	158.00	104.00	79.00	53.10	40.3	950.0	478.0	237.00	156.00	119.00	79.60	60.50
10000	600000	22.200	705.0	353.0	176.00	118.00	88.00	59.00	44.8	1055.0	530.0	264.00	175.00	132.00	88.50	67.10
15000	900000	33.400	1058.0	531.0	264.00	177.00	132.00	88.50	67.2	1582.0	795.0	396.00	262.00	198.00	113.00	100.00
20000	1200000	44.500	1410.0	708.0	352.00	236.00	176.00	118.00	89.6	2110.0	1060.0	528.00	350.00	264.00	177.00	134.00

How to Use Table No. 1—Supposing you wished to install a pump capable of delivering enough water to irrigate 2 acres of land 2 in. deep every 24 hours. Then reading Table No. 1 under "2" column of sub-heading "Acres irrigated in 24 hours," you would find that a pump of 80 gal. per min. capacity would be sufficient. To get the same amount in 16 hours would require a pump delivering 125 gal. per min. In 10 hours, 300 gal. per min.

Weir Tables

In the following tables marginal figures refer to inches and fractions thereof. The figures in the body of each table refer to gallons per minute.

12-INCH WEIR WITH FULL CONTRACTIONS

	0 in.	⅛ in.	¼ in.	⅜ in.	½ in.	⅝ in.	¾ in.	⅞ in.
0 in.	....	1.58	4.48	8.33	12.67	17.65	23.14	29.09
1 in.	35.46	42.29	49.40	56.86	63.16	72.71	81.07	89.79
2 in.	98.68	107.85	117.22	126.83	136.67	146.81	157.05	167.49
3 in.	178.27	188.93	199.93	211.19	222.52	234.01	245.66	257.45
4 in.	269.39	281.53	293.80	306.14	318.67	331.21	344.36	356.90
5 in.	369.86	382.94	396.09	409.26	422.73	436.33	449.89	463.55
6 in.	477.29	491.12	505.04	519.17	533.24	547.40	561.63	575.91
7 in.	590.27	604.78	619.35	633.90	648.52	663.19	677.92	692.84
8 in.	707.68	722.56	737.49	752.47	767.50	782.70	797.81	812.95
9 in.	828.14	843.34	858.61	874.23	889.35	904.68	920.05	935.44
10 in.	950.85	966.37	981.91	997.38	1012.88	1028.40	1043.92	1059.61
11 in.	1075.17	1090.73	1106.30	1121.88	1136.65	1153.21	1168.80	1184.40
12 in.	1200							

2-FOOT WEIR WITH FULL CONTRACTIONS

	0 in.	⅛ in.	¼ in.	⅜ in.	½ in.	⅝ in.	¾ in.	⅞ in.
0 in.	....	3.18	8.98	16.72	25.44	35.48	46.58	58.62
1 in.	71.52	85.38	99.85	114.05	127.94	147.44	164.58	182.48
2 in.	200.78	219.63	238.00	258.89	279.26	300.33	321.65	343.41
3 in.	365.92	388.25	411.30	434.98	458.83	483.07	507.70	532.68
4 in.	558.02	583.98	609.99	636.37	663.17	690.09	718.32	745.37
5 in.	773.34	801.62	830.16	858.80	888.11	917.79	947.47	977.42
6 in.	1007.62	1038.16	1068.80	1100.07	1131.29	1162.74	1194.45	1226.36
7 in.	1258.51	1291.21	1323.82	1356.65	1389.68	1422.92	1456.39	1490.35
8 in.	1524.24	1558.30	1592.55	1627.02	1661.66	1696.82	1731.85	1767.04
9 in.	1802.42	1839.46	1873.71	1910.37	1946.00	1982.22	2018.62	2055.16
10 in.	2091.87	2129.12	2166.13	2203.29	2240.62	2278.09	2315.69	2353.80
11 in.	2391.70	2429.73	2467.89	2506.20	2542.81	2583.57	2622.24	2661.06
12 in.	2700.00							

3-FOOT WEIR WITH FULL CONTRACTIONS

	0 in.	⅛ in.	¼ in.	⅜ in.	½ in.	⅝ in.	¾ in.	⅞ in.
0 in.	....	5	13.5	25	38	53.5	70	88
1 in.	107.5	128.5	150.5	172	192.5	222	248	275
2 in.	303	331.5	360	391	422	454	486	519.5
3 in.	553.5	587.5	622.5	659	695	732	769.5	808
4 in.	846.5	886.5	926	966.5	1007.5	1049	1092.5	1134
5 in.	1177	1220.5	1264	1308.5	1353.5	1399.5	1445	1491.5
6 in.	1538	1585	1632.5	1681	1729.5	1778	1827.5	1877
7 in.	1927	1977.5	2028.5	2079.5	2131	2182.5	2235	2288
8 in.	2341	2394	2447.5	2501.5	2556	2611	2666	2721
9 in.	2776.5	2835	2889	2946.5	3002.5	3060	3117	3175
10 in.	3233	3292	3350.5	3409	3468.5	3528	3587.5	3648
11 in.	3708	3769	3829.5	3890.5	3949	4014	4075.5	4137.5
12 in.	4200							

Pumps

In general pumps should be installed as near the water as practical and the table below shows the *practical suction lift of pumps at different heights above the sea level. These values should not be exceeded, in fact the smaller the suction lift the better. If the water is to be raised from depths which exceed these figures, the pump must be placed in a pit or one of the many types of deep well pumps used.

Elbows or sharp turns in pipes should be avoided as far as possible, as each one increases the friction and makes an appreciable difference in the h.p. required.

SUCTION LIFT OF PUMPS WITH BAROMETRIC PRESSURE AT DIFFERENT ALTITUDES AND EQUIVALENT HEAD OF WATER

Altitude Above Sea Level	Barometric Pressure Lb. per Sq. In.	Equivalent Head of Water	*Practical Suction Lift of Pumps
Sea level	14.70	33.95 ft.	22 ft.
1/4 mile (1320 ft.)	14.02	32.38 ft.	21 ft.
1/2 mile (2640 ft.)	13.33	30.79 ft.	20 ft.
3/4 mile (3960 ft.)	12.66	29.24 ft.	18 ft.
1 mile (5280 ft.)	12.02	27.76 ft.	17 ft.
1 1/4 miles (6600 ft.)	11.42	26.38 ft.	16 ft.
1 1/2 miles (7920 ft.)	10.88	25.13 ft.	15 ft.
2 miles (10560 ft.)	9.98	22.82 ft.	14 ft.

* Practical suction lift of pumps is equal to the vertical distance which water is to be lifted plus the head due to friction.

How to Determine the Horse Power Required to Drive the Pump

(Approximate Method)

Add the friction head as shown in table No. 2, page 58, to the lift in feet, multiply by the gallons per minute pumped and divide by 4000. This is the theoretical horse power.

To get the actual horse power of the motor multiply by the following numbers according to the capacity of the pump in gal. per min.

* Pumps having a capacity of:

1 to 30 gal. per min. multiply theoretical h.p. by 4.
30 to 125 gal. per min. multiply theoretical h.p. by 3.
125 to 1000 gal. per min. multiply theoretical h.p. by 2.
1000 to 5000 gal. per min. multiply theoretical h.p. by 1.5.
5000 to 20,000 gal. per min. multiply theoretical h.p. by 1.4.

Example:

To determine how much power is required to lift 300 gallons a minute 10 ft. and deliver it through a 6 in. pipe 800 ft. from the pump.

In table No. 2 the friction loss is given as 0.85 ft. per 100 ft. of pipe, 0.85×8 (number of hundred feet of pipe used) equals 6.8 ft. friction loss.

6.8 (friction loss) plus 10 (ft. lift) equals 16.8, the total head or pressure the pump must work against in delivering 300 gal. per min. $\frac{16.8 \times 300 \text{ (gal. per min.)}}{4000} = 1.26$ the theoretical horse power. This value must be multiplied by 2, as the capacity of the pump is between 125 and 1000 gallons per minute, which means that a 2.5 h.p. motor is the size required in this particular case.

In case the horse power required for a pneumatic system (air pressure) is to be determined, convert the pounds pressure per square inch carried by the tank into feet head. (See table No. 4, page 61); add to this the height of the tank above the water in the well. This gives the equivalent head in feet, which the pump will have to work against. The horse power of the motor necessary can then be determined as in the preceding example.

Detailed Methods of Determining Size of Motor and Size of Pipe

The following examples and tables give in detail the necessary data and illustrate the methods used in determining the size of motor and pipe necessary for a given installation.

Table No. 3, page 60, gives the theoretical horse power required to lift various quantities of water to different heights. Below is a smaller table of constants for converting theoretical horse power into actual horse power according to the size of the pump.

Table No. 2, page 58, shows the friction head per 100 ft. for different sizes of pipe and its equivalent in theoretical horse power. The friction loss in the pipe depends on its size and the amount of water flowing through it in a given time. For short lengths of pipe this friction loss may be relatively high per 100 ft., but when water is forced for long distances the loss per 100 ft. must be kept low or the power cost will be excessive. To illustrate:

Suppose it is required to deliver 500 gal. per min. 2000 ft. from the pump. How many horse power would have to be used in overcoming the friction loss in a 4 inch, 5 inch, 6 inch, 7 inch or 8 inch pipe? A 4 inch pipe would require 2.16 horse power per 100 ft. (see page 58) or 20 (number of 100 ft.) times 2.16 horse power gives 43.2 horse power. For practical purposes this should be doubled, and 86.4 horse power would be required to overcome the friction loss when pumping 500 gal. per min. through 2000 ft. of 4 inch pipe.

Therefore, the friction loss for 2000 ft. of pipe when pumping 500 gal. per min. would be:

Diameter of Pipe in Inches	Theoretical H.P.	† Actual H.P. Necessary
4	43.2	86.4
5	13.9	27.8
6	5.8	11.6
7	2.54	5.08
8	1.42	2.84

† See footnote, table No. 3, page 60, for the reason why the theoretical horse-power was doubled.

The above table proves conclusively that care should be taken to select the proper sized pipe. If a small pipe is to be used, the increased first cost of the driving unit and the cost of the additional power required should be carefully compared with the increased first cost of the large pipe.

How to Use Tables Two and Three

Example:

How many horse power will be required to pump 500 gal. per min. 100 ft. high and deliver it 400 ft. from the pump; using a 5 in. pipe?

First determine the friction loss in horse power as given in table No. 2, page 58. Reading along the line horizontally from 500 gal. per min. and under the column headed "5 inch pipe" is found the number 0.695 which is the horse power necessary to force 500 gal. per min. through 100 ft. of a 5 in. pipe. In this case we have 500 ft. of pipe (400 ft. of horizontal pipe plus 100 ft. of vertical pipe), which means that 0.695 horse power must be multiplied by 5, giving 3.475 horse power. Next determine the theoretical horse power required to pump 500 gal. per min. 100 ft. high. We find from table No. 3, page 60, that 12.5 h.p. is required.

Add to this the friction loss of 3.475 horse power, which gives a total of 15.975 theoretical horse power. This theoretical horse power must be multiplied by 2 (see footnote No. 3, page 60) giving 31.94 horse power or roughly 32 horse power.

If 50 gal. per min. are to be pumped 20 ft. high and delivered 80 ft. from the well through a 2 in. pipe, a 1 horse power motor would be sufficient.

0.071 horse power (friction loss) $+0.25$ horse power (power to raise the water 20 ft.) $=0.321$ horse power.

0.321×3 (see footnote table No. 3) $=0.963$ horse power or roughly 1 horse power.

Air Pressure System:

Suppose an air pressure system which is intended to operate under a pressure of 40 lb. per sq. in. is required, the tank to be located 50 ft. above the pump and the pump to be 50 ft. in a horizontal direction from the tank, and the pumping equipment to have a capacity of 20 gal. per min. The pipes to be 1¼ inches in diameter. Convert the 40 lb. per sq. in. into equivalent feet head (see table No. 4, page 61), which is 92.36 ft.; this added to 50 ft. lift gives a total of 142.36 ft.

The friction loss in the pipe is 0.047 horse power (see table No. 2); the horse power required for the lift is 0.75 horse power (see table No. 3); adding the two gives 0.797 horse power and multiplying by 4 (see footnote, table No. 3) gives 3.19 horse power, and therefore a 3 horse power motor would be large enough to do the work.

TABLE No. 2—FRICTIONAL LOSS IN FEET AND HORSE POWER PER 100 FEET OF CLEAN IRON PIPE

Gallons per Minute	¾ in. Pipe		1 in. Pipe		1¼ in. Pipe		1½ in. Pipe		2 in. Pipe		2½ in. Pipe		3 in. Pipe		3½ in. Pipe		4 in. Pipe		5 in. Pipe		6 in. Pipe		7 in. Pipe	
	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power
5	7.6	0.01	1.9		0.7		0.27		0.09		0.05		0.01											
10	29.9	0.074	7.3	0.018	1.4	0.004	1.00	0.003	0.28		0.09		0.05		0.01									
15	66.0	0.251	16.1	0.061	5.5	0.021	2.20	0.008	0.57	0.002	0.18		0.09		0.05		0.02							
20	115.0	0.572	28.0	0.142	9.5	0.047	4.80	0.024	0.96	0.005	0.32	0.002	0.13		0.07		0.03		0.01					
25	179.0	1.13	43.7	0.272	14.7	0.093	6.00	0.038	1.70	0.011	0.48	0.003	0.23	0.002	0.09		0.05		0.02		0.01			
30	264.0	2.00	63.2	0.480	21.0	0.160	8.60	0.065	2.10	0.016	0.69	0.005	0.30	0.002	0.14		0.07		0.03		0.01			
35	372.0	3.30	85.1	0.750	28.9	0.256	11.60	0.100	2.70	0.624	0.92	0.008	0.39	0.003	0.20	0.002	0.11		0.04		0.02			
40	461.0	4.67	110.0	1.110	37.0	0.375	14.90	0.151	3.70	0.037	1.20	0.012	0.53	0.005	0.25	0.003	0.14	0.001	0.05		0.02			
45	594.0	6.75	145.0	1.650	46.5	0.530	18.70	0.212	4.60	0.052	1.50	0.017	0.64	0.007	0.32	0.004	0.16	0.002	0.07	0.001	0.02			
50			185.0	2.340	57.3	0.725	23.00	0.290	5.60	0.071	1.90	0.024	0.80	0.010	0.39	0.005	0.20	0.003	0.09	0.001	0.03		0.01	
60			253.0	3.840	82.8	1.260	32.00	0.490	8.00	0.121	2.70	0.041	1.20	0.018	0.55	0.008	0.30	0.005	0.11	0.002	0.05	0.001	0.01	
70			340.0	6.000	116.0	2.060	46.00	0.815	11.00	0.195	3.50	0.062	1.40	0.025	0.87	0.015	0.44	0.008	0.16	0.003	0.06	0.001	0.02	
75			393.0	7.460	129.0	2.450	51.40	0.976	12.20	0.232	4.10	0.078	1.70	0.032	0.90	0.017	0.48	0.009	0.17	0.003	0.07	0.001	0.02	
80			442.0	8.920	147.0	2.980	57.50	1.170	14.50	0.294	4.60	0.097	2.00	0.040	0.93	0.019	0.53	0.011	0.18	0.004	0.07	0.002	0.03	0.001
90			582.0	13.200	184.0	4.190	73.60	1.670	17.90	0.408	5.90	0.135	2.50	0.057	1.10	0.025	0.60	0.014	0.21	0.005	0.09	0.002	0.04	0.001
100					228.0	5.760	89.70	2.270	21.70	0.550	7.30	0.184	2.90	0.074	1.50	0.038	0.74	0.019	0.27	0.007	0.11	0.003	0.05	0.001
125					367.0	11.600	150.00	4.750	34.30	1.080	10.00	0.316	4.60	0.145	2.10	0.066	1.20	0.038	0.39	0.012	0.16	0.005	0.07	0.002
150					516.0	19.600	207.00	7.850	48.80	1.860	16.10	0.606	6.50	0.247	3.10	0.118	1.60	0.061	0.57	0.022	0.23	0.009	0.09	0.003
175							294.00	13.000	64.60	2.850	21.70	0.960	8.60	0.381	4.20	0.186	2.10	0.093	0.78	0.035	0.30	0.013	0.11	0.005
200							359.00	18.200	86.20	4.360	28.60	1.450	11.50	0.582	5.40	0.274	2.80	0.142	0.96	0.048	0.39	0.020	0.16	0.008
225							455.00	25.900	110.00	6.250	36.20	2.060	14.40	0.820	6.70	0.382	3.40	0.194	1.20	0.068	0.45	0.026	0.21	0.012
250							600.00	37.900	137.00	8.650	41.70	2.640	17.70	1.120	8.50	0.537	4.30	0.272	1.50	0.095	0.60	0.038	0.28	0.018
300									195.00	14.800	64.40	4.880	25.70	1.950	11.50	0.872	6.20	0.470	2.10	0.160	0.85	0.064	0.39	0.029
350									258.00	22.900	86.80	7.680	34.90	3.900	16.30	1.450	8.40	0.745	2.90	0.257	1.10	0.097	0.53	0.047
400									345.00	34.800	114.00	11.500	44.90	4.540	21.30	2.150	10.90	1.100	3.70	0.374	1.50	0.151	0.69	0.069
450									439.00	50.000	145.00	16.500	57.50	6.550	26.90	3.060	13.80	1.570	4.60	0.525	1.80	0.205	0.85	0.097
500									549.00	69.400	167.00	21.100	70.80	8.950	33.40	4.220	17.10	2.160	5.50	0.695	2.30	0.290	1.00	0.127
600									780.00	118.000	251.00	38.100	103.00	15.630	46.00	6.990	24.50	3.720	8.40	1.280	3.30	0.500	1.60	0.243
750											375.00	71.200	159.00	30.200	76.50	14.500	38.70	7.350	13.50	2.560	5.10	0.970	2.30	0.436
1000											670.00	169.500	283.00	71.800	134.00	33.900	68.40	17.300	22.00	5.570	9.00	2.280	4.10	1.040
1200													412.00	125.000	184.00	55.900	98.00	29.800	33.60	10.200	12.90	3.920	6.40	1.950
1600															337.00	136.400	174.00	70.500	59.70	24.200	22.90	9.280	11.40	4.620
2000															534.00	270.000	273.00	138.500	88.00	44.600	35.60	18.000	16.40	8.300
2500																	427.00	269.000	138.00	87.000	55.70	35.200	25.60	16.200
3000																	615.00	467.000	198.00	135.000	81.00	61.500	36.90	27.900

TABLE No. 2—FRICTIONAL LOSS IN FEET AND HORSE POWER PER 100 FEET OF CLEAN IRON PIPE—(Continued)

Gallons per Minute	8 IN. PIPE		9 IN. PIPE		10 IN. PIPE		12 IN. PIPE		14 IN. PIPE		16 IN. PIPE		18 IN. PIPE		20 IN. PIPE		22 IN. PIPE		24 IN. PIPE		30 IN. PIPE		36 IN. PIPE	
	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power	Friction Head in Feet	Horse Power
200	0.10	0.005	0.05	0.003	0.04	0.002	0.02	0.001																
225	0.11	0.006	0.06	0.003	0.04	0.002	0.02	0.001																
250	0.15	0.009	0.09	0.006	0.05	0.003	0.02	0.001																
300	0.21	0.016	0.11	0.008	0.07	0.005	0.03	0.002																
350	0.28	0.024	0.16	0.014	0.10	0.009	0.04	0.004																
400	0.37	0.037	0.21	0.021	0.13	0.013	0.05	0.005																
450	0.43	0.049	0.25	0.028	0.15	0.017	0.06	0.007																
500	0.56	0.071	0.32	0.041	0.20	0.025	0.08	0.010																
600	0.80	0.122	0.44	0.067	0.27	0.041	0.11	0.017	0.06	0.009	0.03	0.005	0.01	0.002	0.01	0.602								
750	1.40	0.266	0.69	0.131	0.41	0.078	0.18	0.034	0.09	0.015	0.05	0.010	0.03	0.005	0.02	0.003								
1000	2.20	0.557	1.20	0.304	0.73	0.185	0.30	0.076	0.14	0.035	0.08	0.020	0.04	0.010	0.03	0.007	0.02	0.006	0.02	0.006	0.01	0.003		
1200	3.10	0.942	1.76	0.535	1.03	0.313	0.42	0.128	0.20	0.061	0.10	0.030	0.06	0.018	0.04	0.012	0.04	0.016	0.03	0.012	0.01	0.004		
1600	5.80	2.350	3.10	1.250	1.80	0.729	0.74	0.300	0.35	0.142	0.18	0.072	0.10	0.040	0.06	0.024	0.06	0.030	0.04	0.020	0.02	0.010	0.01	0.005
2000	8.50	4.300	4.80	2.430	2.80	1.420	1.20	0.608	0.54	0.274	0.28	0.142	0.16	0.081	0.10	0.050	0.09	0.057	0.06	0.038	0.02	0.013	0.01	0.006
2500	13.30	8.400	7.50	4.750	4.40	2.780	1.80	1.140	0.84	0.531	0.43	0.272	0.25	0.158	0.15	0.095	0.13	0.100	0.09	0.068	0.03	0.023	0.01	0.008
3000	19.80	15.000	10.80	8.200	6.30	4.780	2.60	1.970	1.20	0.910	0.62	0.470	0.35	0.265	0.21	0.159	0.18	0.160	0.12	0.106	0.04	0.035	0.02	0.018
3500					8.52	7.55	4.18	3.71	1.70	1.500	0.84	0.740	0.47	0.416	0.28	0.248	0.23	0.232	0.15	0.152	0.05	0.050	0.02	0.020
4000							4.45	4.50	2.10	2.120	1.09	1.100	0.61	0.617	0.36	0.364	0.28	0.319	0.19	0.216	0.06	0.068	0.03	0.024
4500							5.51	6.30	2.70	3.080	1.40	1.590	0.77	0.875	0.46	0.525	0.35	0.442	0.23	0.291	0.08	0.101	0.03	0.038
5000							6.65	8.33	3.40	4.300	1.70	2.150	0.94	1.190	0.56	0.710	0.42	0.575	0.28	0.390	0.09	0.125	0.04	0.056
5500									4.10	5.700	2.10	2.920	1.14	1.590	0.68	0.950	0.90	1.830	0.58	1.180	0.19	0.385	0.08	0.162
8000									8.40	17.000	4.40	8.900	2.40	4.860	1.40	2.840	1.20	2.740	0.73	1.660	0.24	0.550	0.10	0.228
9000									10.60	24.200	5.50	12.500	3.10	7.100	1.80	4.100	1.40	3.540	0.92	2.330	0.30	0.760	0.13	0.329
10000									13.40	33.400	6.70	16.900	3.80	9.600	2.20	5.560	2.10	6.400	1.40	4.250	0.43	1.300	0.17	0.515
12000									19.10	57.600	9.90	30.000	5.60	16.900	3.40	10.300	2.70	9.560	1.80	6.370	0.58	2.060	0.24	0.850
14000									26.30	89.500	13.10	46.400	7.40	26.200	4.40	15.600	4.80	21.900	2.90	13.200	0.96	4.370	0.38	1.730
18000									42.40	193.000	22.00	100.000	12.40	56.500	7.20	32.800	6.70	37.200	4.50	25.000	1.50	8.350	0.63	3.510
22000									65.10	363.000	32.20	179.000	18.20	101.000	10.90	60.800								

TABLE No. 3—THEORETICAL HORSE POWER REQUIRED TO RAISE WATER TO DIFFERENT HEIGHTS

Gal. per Min.	FEET LIFT																					
	5	10	15	20	25	30	35	40	45	50	60	75	90	100	125	150	175	200	250	300	350	400
1	0.001	0.003	0.004	0.005	0.006	0.008	0.009	0.010	0.11	0.013	0.015	0.019	0.023	0.025	0.032	0.038	0.044	0.05	0.06	0.08	0.09	0.10
2.5	0.003	0.006	0.010	0.013	0.016	0.019	0.022	0.025	0.029	0.031	0.038	0.047	0.057	0.063	0.079	0.095	0.110	0.13	0.16	0.19	0.22	0.25
5	0.006	0.012	0.019	0.025	0.031	0.037	0.044	0.050	0.060	0.060	0.070	0.090	0.110	0.120	0.160	0.190	0.220	0.25	0.31	0.37	0.44	0.50
10	0.012	0.025	0.037	0.050	0.062	0.075	0.087	0.100	0.110	0.120	0.150	0.190	0.220	0.250	0.310	0.370	0.440	0.50	0.62	0.75	0.87	1.00
15	0.019	0.037	0.056	0.075	0.094	0.112	0.131	0.150	0.170	0.190	0.220	0.280	0.340	0.370	0.470	0.560	0.660	0.75	0.94	1.12	1.31	1.50
20	0.025	0.050	0.075	0.100	0.125	0.150	0.175	0.200	0.22	0.250	0.300	0.370	0.450	0.500	0.620	0.750	0.870	1.00	1.25	1.50	1.75	2.00
25	0.031	0.062	0.093	0.125	0.156	0.187	0.219	0.25	0.28	0.310	0.370	0.470	0.560	0.620	0.780	0.940	1.090	1.25	1.56	1.87	2.19	2.50
30	0.037	0.075	0.112	0.150	0.187	0.225	0.262	0.30	0.34	0.370	0.450	0.560	0.670	0.750	0.940	1.120	1.310	1.50	1.87	2.25	2.62	3.00
35	0.043	0.087	0.131	0.175	0.219	0.262	0.306	0.35	0.39	0.440	0.520	0.660	0.790	0.870	1.080	1.310	1.530	1.75	2.19	2.62	3.06	3.50
40	0.050	0.100	0.150	0.200	0.250	0.300	0.350	0.40	0.45	0.500	0.600	0.750	0.900	1.000	1.250	1.500	1.750	2.00	2.50	3.00	3.50	4.00
45	0.056	0.112	0.168	0.225	0.281	0.337	0.394	0.45	0.51	0.560	0.670	0.840	1.010	1.120	1.410	1.690	1.970	2.25	2.81	3.37	3.94	4.50
50	0.062	0.125	0.187	0.250	0.312	0.375	0.437	0.50	0.56	0.620	0.750	0.940	1.120	1.250	1.560	1.870	2.190	2.50	3.12	3.75	4.37	5.00
60	0.075	0.150	0.225	0.300	0.375	0.450	0.525	0.60	0.67	0.750	0.900	1.120	1.350	1.500	1.870	2.250	2.620	3.00	3.75	4.50	5.25	6.00
75	0.093	0.187	0.281	0.375	0.469	0.562	0.656	0.75	0.84	0.940	1.120	1.400	1.690	1.870	2.340	2.810	3.280	3.75	4.69	5.62	6.56	7.50
90	0.112	0.225	0.337	0.450	0.562	0.675	0.787	0.90	1.01	1.120	1.350	1.680	2.020	2.250	2.810	3.370	3.940	4.50	5.62	6.75	7.87	9.00
100	0.125	0.250	0.375	0.500	0.625	0.750	0.875	1.00	1.12	1.250	1.500	1.870	2.250	2.500	3.120	3.750	4.370	5.00	6.25	7.50	8.75	10.00
125	0.156	0.312	0.469	0.625	0.781	0.937	1.094	1.25	1.41	1.560	1.870	2.340	2.810	3.120	3.910	4.690	5.470	6.25	7.81	9.37	10.94	12.50
150	0.187	0.375	0.562	0.750	0.937	1.125	1.312	1.50	1.69	1.870	2.250	2.810	3.370	3.750	4.690	5.620	6.560	7.50	9.37	11.25	13.12	15.00
175	0.219	0.437	0.656	0.875	1.093	1.312	1.531	1.75	1.97	2.190	2.620	3.280	3.940	4.370	5.470	6.560	7.660	8.75	10.94	13.12	15.31	17.50
200	0.250	0.500	0.750	1.000	1.250	1.500	1.750	2.00	2.25	2.500	3.000	3.750	4.500	5.000	6.250	7.500	8.750	10.00	12.50	15.00	17.50	20.00
250	0.312	0.625	0.937	1.250	1.562	1.875	2.187	2.50	2.81	3.120	3.750	4.690	5.620	6.250	7.810	9.370	10.940	12.50	15.72	18.75	21.87	25.00
300	0.375	0.750	1.125	1.500	1.875	2.250	2.625	3.00	3.37	3.750	4.500	5.620	6.750	7.500	9.370	11.250	13.120	15.00	18.75	22.50	26.25	30.00
350	0.437	0.875	1.312	1.750	2.187	2.625	3.062	3.50	3.94	4.370	5.250	6.560	7.870	8.750	10.940	13.120	15.310	17.50	21.87	26.25	30.62	35.00
400	0.500	1.000	1.500	2.000	2.500	3.000	3.500	4.00	4.50	5.000	6.000	7.500	9.000	10.000	12.500	15.000	17.500	20.00	25.00	30.00	35.00	40.00
500	0.625	1.250	1.875	2.500	3.125	3.750	4.375	5.00	5.62	6.250	7.500	9.370	11.250	12.500	15.620	18.750	21.870	25.00	31.25	37.50	43.75	50.00
600	0.759	1.520	2.280	3.040	3.800	4.560	5.300	6.08	6.83	7.600	9.100	11.400	13.680	15.200	19.000	22.800	26.600	30.40	38.00	45.60	53.00	60.80
700	0.885	1.780	2.660	3.540	4.420	5.300	6.180	7.06	7.95	8.850	10.600	13.250	15.900	17.800	22.100	26.500	30.900	35.40	44.20	53.00	61.80	70.60
800	1.010	2.020	3.040	4.050	5.060	6.070	7.090	8.10	9.12	10.100	12.200	15.200	18.200	20.200	25.300	30.400	35.400	40.50	50.60	60.70	70.90	81.00
900	1.120	2.250	3.370	4.500	5.620	6.750	7.870	9.00	10.10	11.200	13.500	16.800	20.200	22.500	28.100	33.700	39.400	45.00	56.20	67.50	78.70	90.00
1000	1.250	2.500	3.750	5.000	6.250	7.500	8.750	10.00	11.20	12.500	15.000	18.700	22.500	25.000	31.200	37.500	43.700	50.00	62.50	75.00	87.50	100.00
1500	1.870	3.750	5.620	7.500	9.370	11.250	13.200	15.00	16.90	18.700	22.500	28.100	33.700	37.500	46.900	56.200	65.600	75.00	93.70	112.50	131.20	150.00
2000	2.500	5.000	7.500	10.000	12.500	15.000	17.500	20.00	22.50	25.000	30.000	37.500	45.000	50.000	62.500	75.000	87.500	100.00	125.00	150.00	175.00	200.00
2500	3.120	6.250	9.300	12.500	15.600	18.700	21.900	25.00	28.00	31.000	37.00	47.00	56.00	62.00	78.00	94.00	109.00	125.00	156.00	187.00	219.00	250.00
3000	3.700	7.500	11.20	15.00	18.70	22.50	26.20	30.00	34.00	37.00	45.00	56.00	67.00	75.00	94.00	112.00	131.00	150.00	187.00	225.00	262.00	300.00
3500	4.300	8.700	13.10	17.50	21.90	26.20	30.60	35.00	39.00	44.00	52.00	66.00	79.00	87.00	108.00	131.00	153.00	175.00	219.00	262.00	306.00	350.00
4000	5.000	10.000	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00	60.00	75.00	90.00	100.00	125.00	150.00	175.00	200.00	250.00	300.00	350.00	400.00
4500	5.600	11.200	16.80	22.50	28.10	33.70	39.40	45.00	51.00	56.00	67.00	84.00	101.00	112.00	141.00	169.00	197.00	225.00	281.00	337.00	394.00	450.00
5000	6.200	12.50	18.70	25.00	31.20	37.50	43.70	50.00	56.00	62.00	75.00	94.00	112.00	125.00	156.00	187.00	219.00	250.00	312.00	375.00	437.00	500.00
6000	7.50	15.00	22.50	30.00	37.50	45.00	52.50	60.00	67.00	75.00	90.00	112.00	135.00	150.00	187.00	225.00	262.00	300.00	375.00	450.00	525.00	600.00
7000	8.85	17.80	26.60	35.40	44.20	53.00	61.80	70.60	79.50	88.50	106.00	132.50	159.00	178.00	221.00	265.00	309.00	354.00	442.00	530.00	618.00	706.00
8000	10.10	20.20	30.40	40.50	50.60	60.70	70.90	81.00	91.20	101.00	122.00	152.00	182.00	202.00	253.00	304.00	354.00	405.00	506.00	607.00	709.00	810.00
9000	11.20	22.50	33.70	45.00	56.20	67.50	78.70	90.00	101.00	112.00	135.00	168.00	202.00	225.00	281.00	337.00	394.00	450.00	562.00	675.00	787.00	900.00
10000	12.50	25.00	37.50	50.00	62.75	75.00	87.50	100.00	112.00	125.00	150.00	187.00	225.00	250.00	312.00	375.00	437.00	500.00	625.00	750.00	875.00	1000.00
15000	18.70	37.50	56.20	75.00	93.70	112.50	132.00	150.00	169.00	187.00	225.00	281.00	337.00	375.00	469.00	562.00	656.00	750.00	937.00	1125.00	1312.00	1500.00
20000	25.00	50.00	75.00	100.00	125.00	150.00	175.00	200.00	225.00	250.00	300.00	375.00	450.00	500.00	625.00	750.00	875.00	1000.00	1250.00	1500.00	1750.00	2000.00

To get the actual h.p. required, the figures in this table must be multiplied by a number ranging from 1.4 to 4, depending on the capacity of the pump.

Pumps Having a Capacity of

1 to 30 gal. per min. multiply theoretical h.p. by 4.
30 to 125 gal. per min. multiply theoretical h.p. by 3.
125 to 1000 gal. per min. multiply theoretical h.p. by 2.
1000 to 5000 gal. per min. multiply theoretical h.p. by 1.5.
5000 to 20,000 gal. per min. multiply theoretical h.p. by 1.4.

TABLE No. 4

FEET HEAD OF WATER INTO PRESSURE, PER SQUARE INCH

Feet Head	Pounds per Sq. In.	Feet Head	Pounds per Sq. In.	Feet Head	Pounds per Sq. In.
1	.43	60	25.99	200	86.62
2	.87	70	30.32	225	97.45
3	1.30	80	34.65	250	108.27
4	1.73	90	38.98	275	119.10
5	2.17	100	43.31	300	129.93
6	2.60	110	47.64	325	140.75
7	3.03	120	51.97	350	151.58
8	3.40	130	56.30	400	173.24
9	3.90	140	60.63	500	216.55
10	4.33	150	64.96	600	259.85
20	8.66	160	69.29	700	303.16
30	12.99	170	73.63	800	346.47
40	17.32	180	77.96	900	389.78
50	21.65	190	82.29	1000	433.09

PRESSURE PER SQUARE INCH INTO FEET HEAD OF WATER

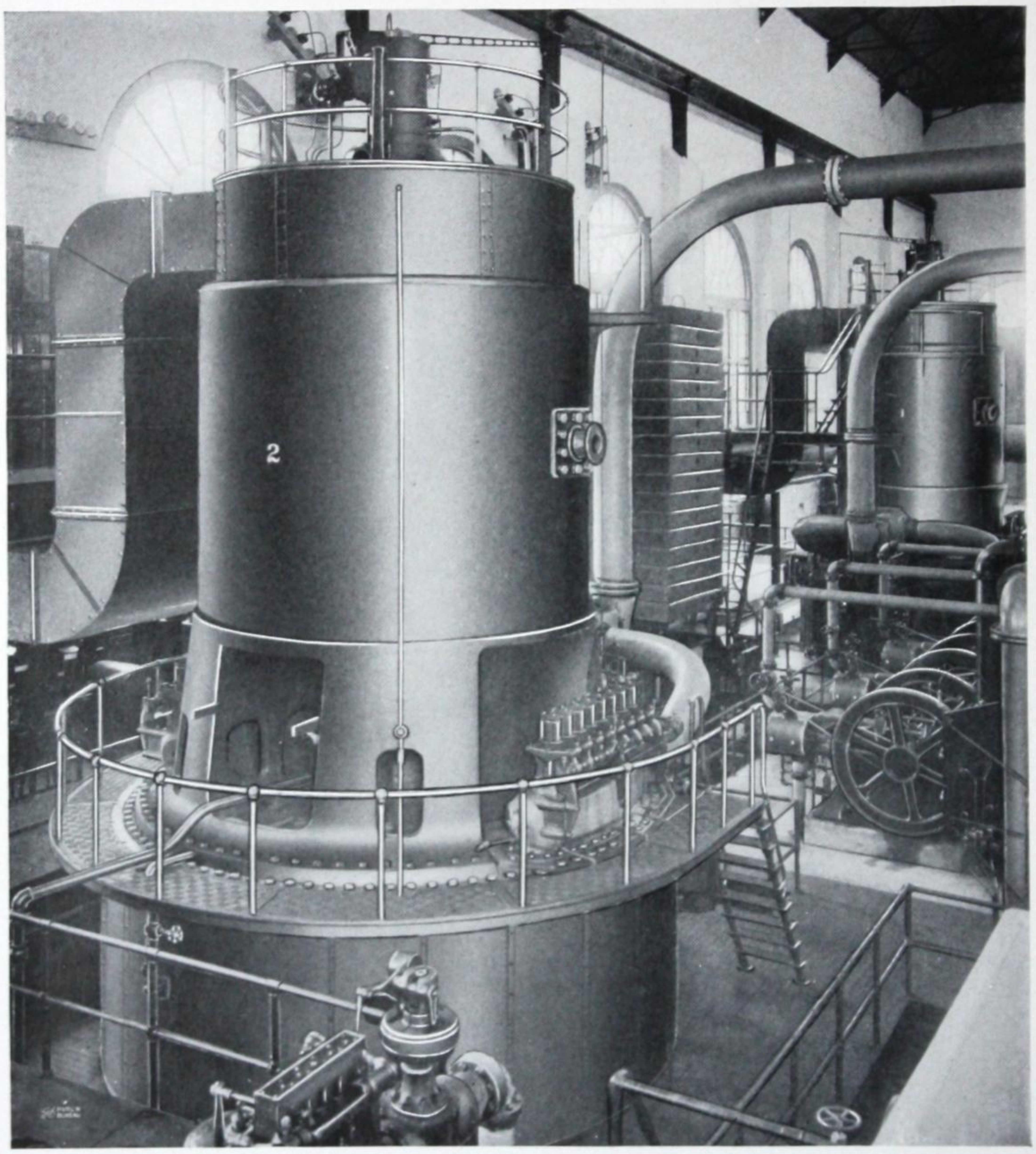
Pounds per Sq. In.	Feet Head	Pounds per Sq. In.	Feet Head	Pounds per Sq. In.	Feet Head
1	2.31	40	92.36	170	392.52
2	4.62	50	115.45	180	415.61
3	6.93	60	138.54	190	438.90
4	9.24	70	161.63	200	461.78
5	11.54	80	184.72	225	519.51
6	13.85	90	207.81	250	577.24
7	16.16	100	230.90	275	643.03
8	18.47	110	253.98	300	692.69
9	20.78	120	277.07	325	750.41
10	23.09	125	288.62	350	808.13
15	34.63	130	300.16	375	865.89
20	46.18	140	323.25	400	922.58
25	57.72	150	346.34	500	1154.48
30	69.27	160	369.43	1000	2308

Convenient Equivalents

1 second-foot equals 40 California miner's inches. (Law of March 23, 1901.)
1 second-foot equals 38.4 Colorado miner's inches.
1 second-foot equals 40 Arizona miner's inches.
1 second-foot equals 7.48 United States gallons per second; equals 448.8 gallons per minute; equals 646,272 gallons per day.
1 second-foot equals 6.23 British imperial gallons per second.
1 second-foot equals about one acre-inch per hour.
100 California miner's inches equal 15.7 United States gal. per second.
100 California miner's inches equal 96.0 Colorado miner's inches.
100 California miner's inches for one day equal 4.96 acre-feet.
100 Colorado miner's inches equal 2.60 second-feet.
100 Colorado miner's inches equal 19.5 United States gal. per second.
100 Colorado miner's inches equal 130 California miner's inches.
100 Colorado miner's inches for one day equal 5.17 acre-feet.
100 United States gallons per minute equal 0.223 second-feet.
100 United States gallons per minute for one day equal 0.442 acre-feet.
1 acre-foot equals 325,850 gallons.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 mile equals 1760 yards; equals 5280 feet; equals 63,360 inches.
1 acre equals 43,560 square feet; equals 4840 square yards.
1 cubic foot equals 7.48 gallons.
1 cubic foot of water weighs 62.5 pounds.
1 gallon equals 8.36 pounds of water.
1 gallon equals 231 cubic inches (liquid measure).

How to Get Electricity

The most practical and economical method of securing electricity for farm use is to purchase it from the local electric light company whenever possible, as such a company can, as a rule, deliver the electric current to the farm more cheaply than the farmer can generate it by means of an isolated plant. The reason for this is that the central station companies make the generation and distribution of electricity their specialty. They



9000 Kw. Curtis Steam Turbine-Generator in the Power Station of Sierra & San Francisco Power Company, San Francisco, Cal.

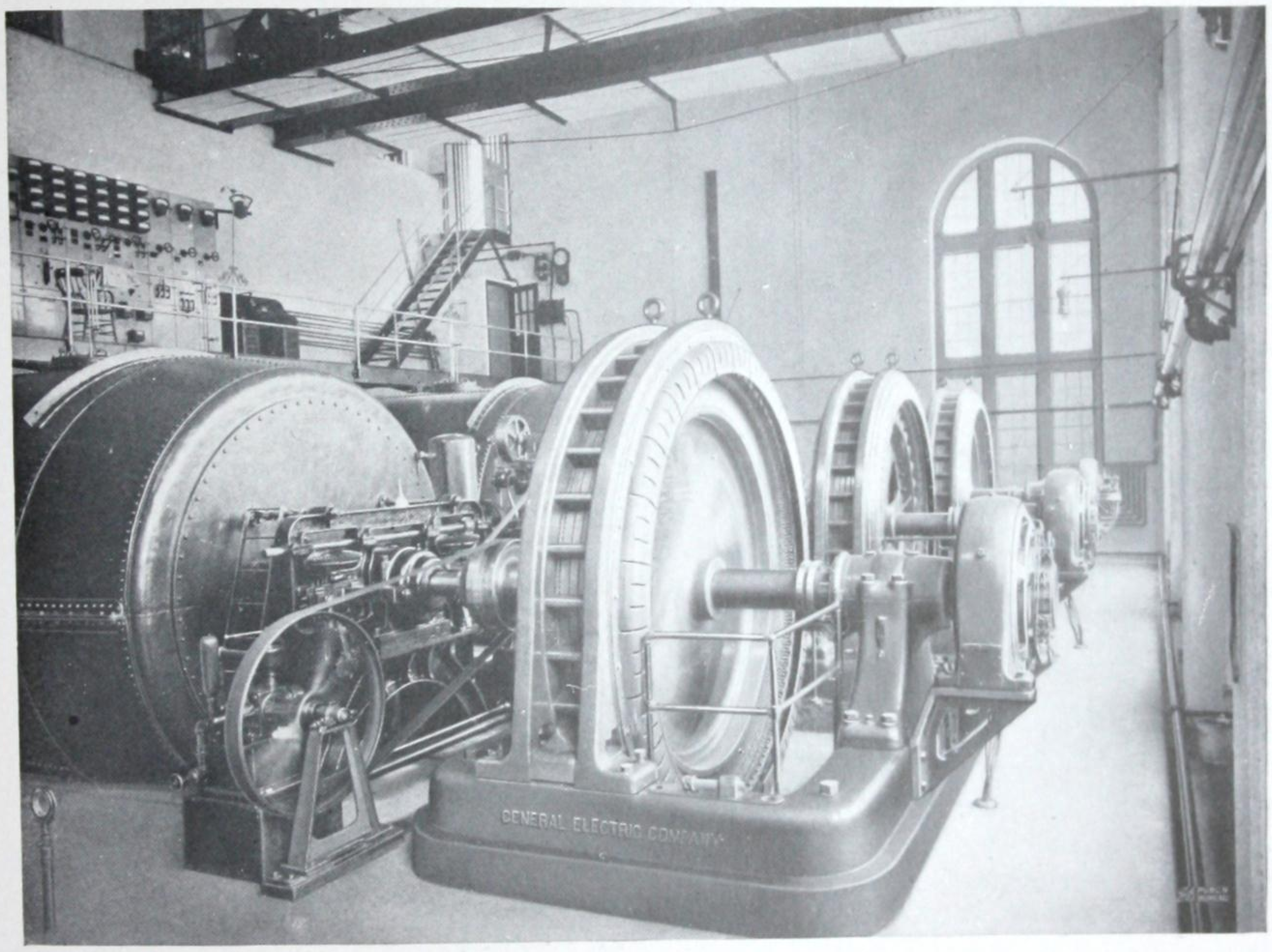
have made a careful study of the problems involved and have reduced the generating cost to its lowest economical basis, and for this reason the isolated plant can no more compete with the central station plant than an individual making his own shoes can compete with a large shoe manufacturer.

In order to produce electricity it is necessary to have an electric generator and also an engine, waterwheel or some other form of power to drive it, and, unless the isolated plant is a water power installation which can be run twenty-four hours a day, it will also

be necessary to install a storage battery for emergency lighting and power, as the average farm does not use enough electric current to warrant running the equipment all the time.

In addition the isolated plant requires a considerable amount of attendance as it is necessary that the engine be started and stopped, that fuel and oil be supplied, and that the storage batteries be kept cleaned and properly charged. All this attendance adds to the cost of producing electric current.

Contrast this with the use of central station power. The equipment needed on the farm is limited to motors, lamps and wiring, which are also necessary in case an isolated plant is installed. Again, if the generating equipment of the isolated plant should fail, the farm is without light and power, as it has no reserve machinery, while



One of the Electric Generating Stations of the Rochester (N.Y.) Railway and Light Co. This company supplies electric current to about 200 rural customers for lighting and power purposes

on the other hand the central station need only start up their reserve generators and the interruption would be of very short duration.

If central station power is used there is the added advantage of having the advice and help of experienced electricians, both while the service is being installed and also in case of operating troubles.

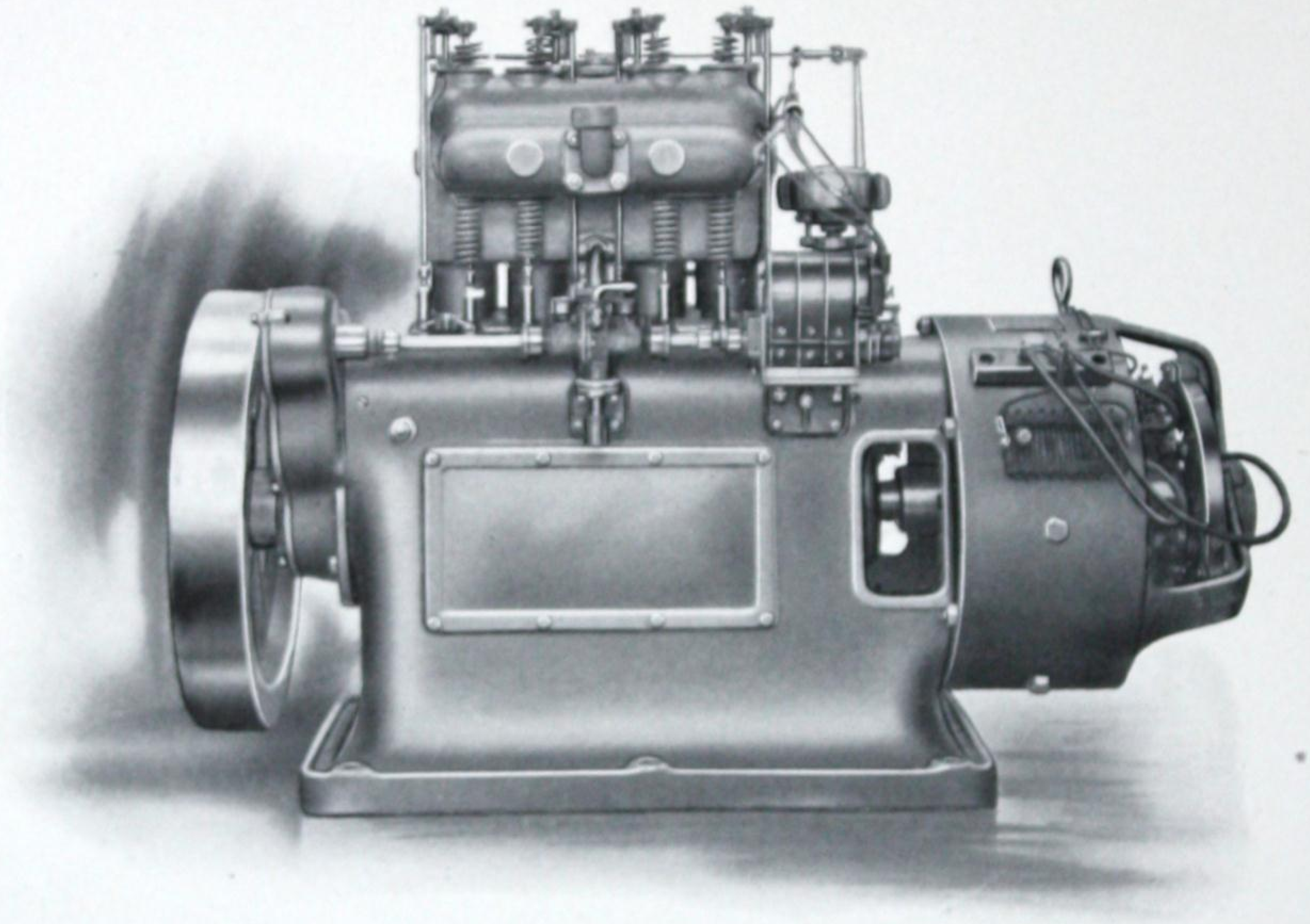
Additional motors can be added with only the cost of the motor itself to consider, while with an isolated plant it may also be necessary to increase the size of the generating equipment in order to get power enough to supply the current required by the increased load.

If it is impossible to secure central station power, then the next cheapest method is the isolated electric plant, which if properly selected and installed will still show a saving over other forms of light and power.

Isolated Generating Plants

For those farms on which central station current cannot be obtained, compact generating sets utilizing various prime movers are now available. The choice of a prime mover will depend largely on local conditions, and in some cases on personal preference. Many farms have been equipped with generators, driven by water power, steam engines and turbines, gasolene engines, and in a few instances by windmills.

The accompanying illustrations show a type of gasolene-electric generating set which has been developed by the General Electric Company, and is especially adapted for farm installations. These sets are the best that experienced designers can plan and skilled workmen construct. They operate quietly and require practically no attention



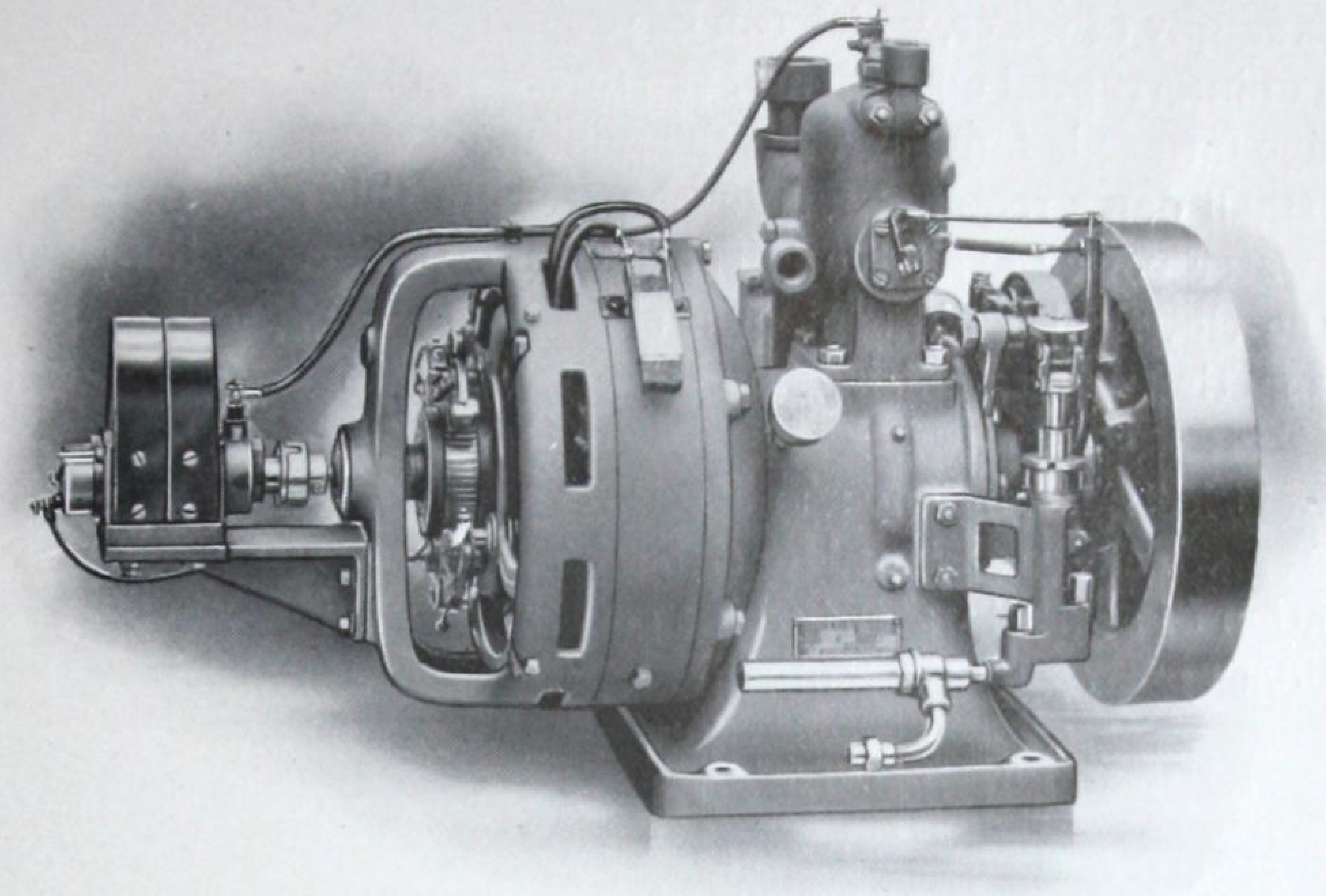
5 Kw. Gasolene-Electric Generating Set

while running. All parts are accessible and are made interchangeable as far as possible. The sets are made in sizes ranging from 1 to 35 h.p. capacity, and generators for either alternating or direct current and of standard voltages can be supplied.

Another advantage of these sets is that the lights can be run directly from the generator and only a small storage battery is required for emergency lighting.

For a farm equipped with steam boilers or accessible to cheap fuel, the General Electric Company has designed small steam engines and turbine-generator sets. The steam engine sets are of the marine type and operate at the usual boiler pressures. Their construction is compact and they therefore occupy very little space, and do not require special foundations.

The turbine-generator sets are of the well known horizontal shaft Curtis type with the turbine and generator compactly mounted on a common base. This type of turbine-generator is extremely simple in operation, automatically controlled, has moderate speed with high steam economy, and is thoroughly reliable in operation. For the sizes usually



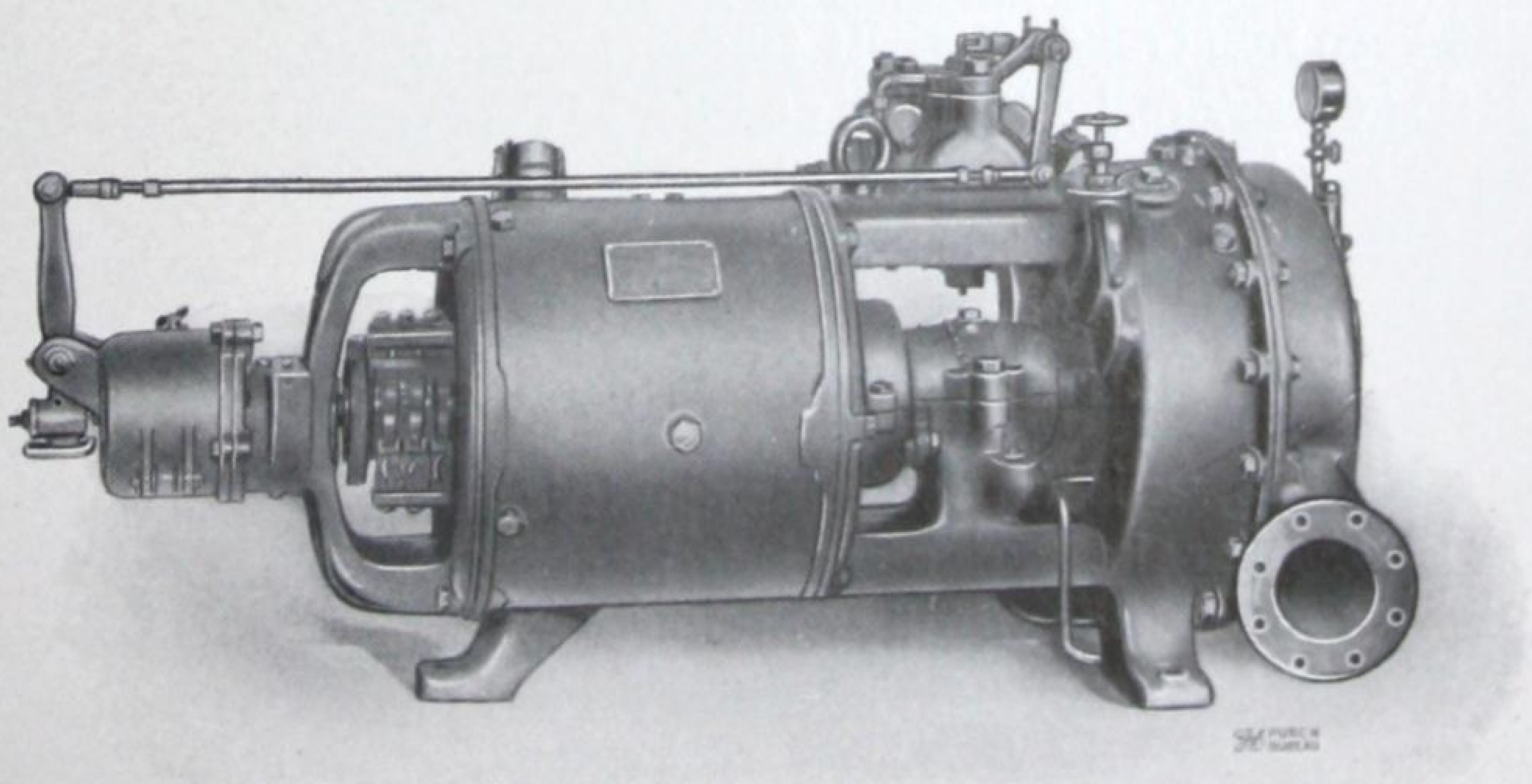
1 Kw. Gasolene-Electric Generating Set

required on farm installations, the turbine sets are arranged to operate at any steam pressure above 80 pounds, either non-condensing or condensing.

For safety in operation, these turbines are in a class by themselves, and cannot be excelled. In addition to the positive and efficient automatic governor they are equipped with an entirely independent emergency governor. The turbines require less floor space than any type of horizontal engine of the same capacity and occupy about the same floor space as vertical engines, but have much less weight. Owing to their light weight, small size and absence of reciprocating parts, heavy foundations are not required.

The exhaust steam from these turbines is absolutely free from oil, and can, therefore, be safely used for heating purposes throughout the farm. The sets operate without vibration, and there is an entire absence of objectionable noise.

On farms situated near available water power, it is sometimes advisable to operate the generating equipment with waterwheels, and there are many notable examples of successful developments of this nature. The most important consideration is an adequate



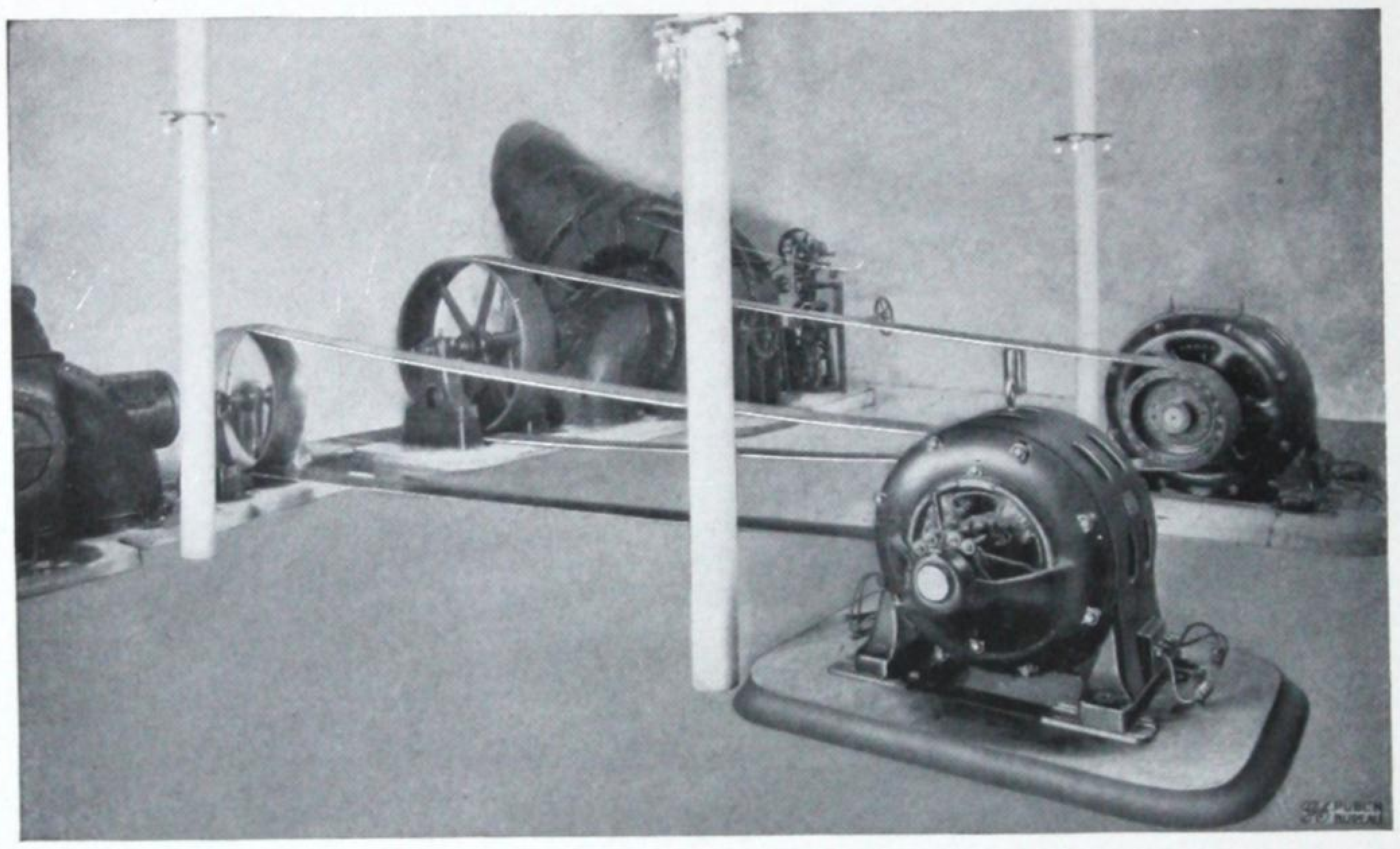
5 Kw. Curtis Steam Turbo-Generator

and continuous supply of water, which can be properly conserved by the building of dams, so as to insure uninterrupted operation of the farm motors.

The average farmer is familiar with the mixing and use of concrete and can usually construct the small dams required for development of this kind without outside assistance. If the water power available is considerably in excess of that required for the operation of the electrical equipment of a single farm, the co-operation of a group of farmers can sometimes accomplish economically what could not be attempted by an individual.

The General Electric Company manufactures a complete line of alternating and direct current generators which are designed for either belt or direct connection to water turbines.

The operation of a small water turbine generating plant when provided with a suitable governor does not require attention except for starting, stopping and lubrication,



Interior View of a Farm Power House, Showing General Electric Alternating Current Generators Belt Connected to Water Turbines

and as there is no cost for fuel, and the maintenance charges are practically negligible, the development of small water powers for farm work has, in many instances, been highly successful.

There have been numerous attempts to develop an efficient windmill equipment for operating electric generators, but while a number of these have been successfully operated in Europe—especially in Denmark—they have not as yet been proved to be adapted to the economical generation of electric power.

Standard and Low Voltage

If central station power is not available and it is decided to install an isolated plant, the question as to whether the equipment is to be standard or low voltage, i.e., more than or less than 100 volts, should be carefully considered. It is practicable to use a low voltage system for lighting, but it cannot be effectively used for power purposes, such as feed grinding, pumping, ensilage cutting, etc. In addition to this, heating devices, such as flatirons, toasters, etc., are not generally available for low voltage circuits and when they can be purchased the price is excessive as compared with standard voltage devices of the same size and capacity.

There is very little demand for low voltage motors and heating devices and, consequently, these have not been developed and standardized in such quantities and varieties as have the standard 110 and 220 volt equipments. For this reason many of the motors needed for farm purposes, if operated on low voltages, would have to be especially designed, which would entail a very large increase in their cost.

It is impracticable to transmit any appreciable amount of electric current at 30 to 60 volts as the wire cost becomes excessive. For instance, the cost of wires large enough to deliver an equivalent of 2 h.p., 250 ft., would be nine times as great for 32 volts as for 100 volts; allowing the same power loss in each case.

Even if an isolated plant is only desired for lighting, there is no argument in favor of the low voltage, except possibly that the cost of the storage battery increases slightly in price as the voltage increases. This slight increase is immaterial, however, when compared with the advantages of the higher over the lower voltages, as a battery capable of operating five 16 c-p. lamps for 8 hours would only cost about $17.00 more than the low voltage equipment.

The absence of fire risk so frequently referred to by the low voltage advocates has no foundation in fact, for the National Board of Fire Underwriters make no distinction between 30 volt and 110 volt circuits as the wiring regulations are the same in both cases. The extra danger of injury from the 110 volt circuit is negligible in any event and there is no necessity for anyone coming in contact with the wires if the equipment is properly installed.

Another argument sometimes advanced is that low voltage tungsten lamps are stronger and cheaper, but this is no longer true as the new Mazda drawn wire filament high voltage lamp is as strong and as cheap as the lamp of low voltage. This is proven by the fact that the electrical railway companies are now installing 110 volt Mazda lamps in their interurban cars, and the Mazda lamp, as used on the farm, will not ordinarily receive as severe treatment as it does in electric railway service.

If central station power should at any time become available the change over can be very readily made if standard voltage equipment is already in use, while with low voltage a complete change of lamps would be necessary. Thus, it can be readily seen that the low voltage plant, if installed, has many disadvantages, the most serious of these being that it makes absolutely no preparation for the future application of motors over 1 h.p., which every farmer will wish to use as soon as he becomes familiar with the immense advantages derived from the use of electric power.

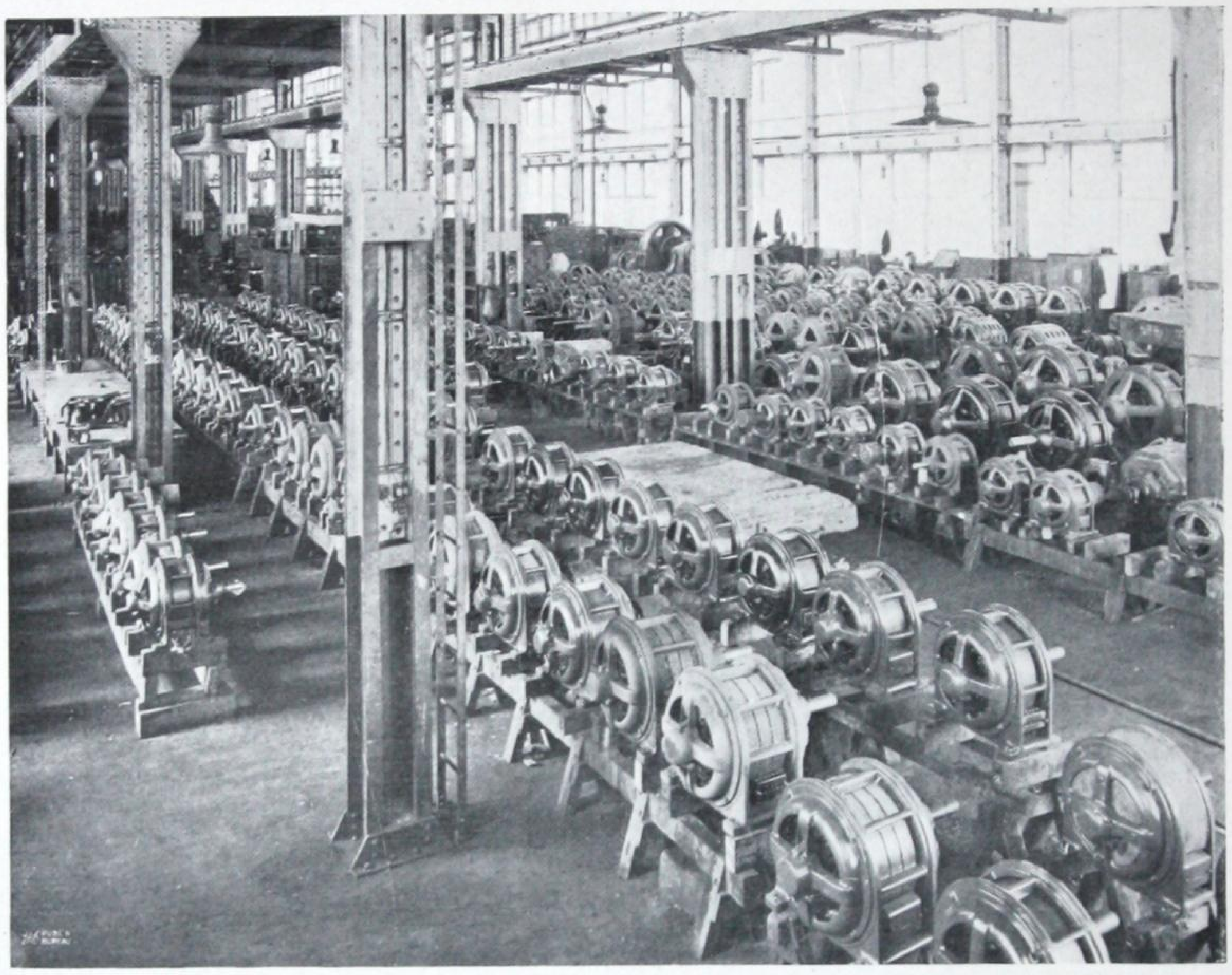
Before installing a farm power plant, the capacity required should be carefully calculated in order to secure the greatest economy. If the plant is to be used for lighting alone, the maximum number of lights in operation at one time will determine the size of the engine and generator. If, however, it is desired to operate some of the farm machines with electric motors the horse power of the plant should be slightly in excess of that required by the largest motor. This will enable a few lights to be burned when the motor is running.

In connection with the power plant, a small storage battery will be sufficient, as it will only be needed to operate lamps in case of an emergency or late at night.

The General Electric Company makes both standard and low voltage generators and lamps, and the only object of this chapter is to point out some of the more important points to be considered when installing an isolated plant for farm use.

Conclusion

Electricity is the most economical form of energy for light and power that can be used in farm service. It is not affected by heat or cold. Very few mechanical adjustments are required. The motors are compact and of light weight for a given capacity. The fire risk is minimized. Electricity can safely be used for over one hundred different farm operations. Electricity effects a marked saving in both time and labor. Electricity eliminates to a large extent the use of costly manual and animal labor.



View in Motor Department of the Schenectady Works of the General Electric Company

The General Electric Company occupies an unique position in the electrical business in that it can furnish from its own shops every electrical device necessary for the complete installation of an electric power plant. Prospective purchasers will find it desirable to place their orders for electrical apparatus with one concern, as by so doing responsibility is not divided, and a complete, uniform, standard outfit will be obtained. In addition to this, the advice of the company's engineers is always at the service of the customer, to assist in determining the most suitable equipment for any given set of conditions.

All products bearing the General Electric Company's Monogram Trademark carry a world wide reputation for sustained excellence in design, material and workmanship.

Information Form to be Filled out and Returned

If you are interested and would like to have prices, answer the questions on this sheet and send it either to the Electric Light & Power Company whose address is stamped on this bulletin or to our nearest sales office. (See page 72.)

Name...Date..........................

Address..........................Town..................................State.........................

Size of farm............................. Do you make a specialty of any particular kind of farming..

How far is your farm from nearest town?..............................Direction....................

Do the lines of any power company run near your farm, if so, how far are they away?

....

How many lights do you wish to install?......................in house?......................

Barns?.........................Yards and driveways?.........................What candle-power do you desire in each case?...

What kind of light are you now using?...

Indicate by a check mark any of the following machines which you wish to operate by electric power:

Cream separators	Ensilage cutters	Root cutters
Pumps	Wood saws	Bone grinders
Churns	Huskers and shredders	Hay balers
Feed grinders	Alfalfa mills	Cider mills
Corn shellers	Grain threshers	Electric irons
Washing machines	Vacuum cleaners	Electric vehicles

Other machines..

....

What kind of power are you now using to operate these machines?........................

What is its equivalent horse power?...

If you wish to use a pump for irrigation, what size pump will you use?...................

What is the total lift in feet?...

How many acres do you wish to irrigate?...

Remarks...

....

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GENERAL ELECTRIC COMPANY

PRINCIPAL OFFICES, SCHENECTADY, N. Y.

SALES OFFICES
(Address nearest office)

ATLANTA, GA.	Third National Bank Building
Birmingham, Ala.	Brown-Marx Building
Jacksonville, Fla.	Heard National Bank Building
New Orleans, La.	Maison-Blanche Building
BOSTON, MASS.	84 State Street
Providence, R. I.	Union Trust Building
Springfield, Mass.	Massachusetts Mutual Building
CHICAGO, ILL.	Monadnock Building
Butte, Mont.	Electric Building
Davenport, Iowa	Security Building
Detroit, Mich.	Dime Savings Bank Bldg. (Office of Soliciting Agent)
Keokuk, Iowa	Monarch Building
Madison, Wis.	Ft. Wayne Works
Milwaukee, Wis.	Public Service Building
Minneapolis, Minn.	410 Third Ave., North
CINCINNATI, OHIO	Provident Bank Building
Chattanooga, Tenn.	James Building
Cleveland, Ohio	Citizens Building
Columbus, Ohio	Columbus Savings & Trust Building
Dayton, Ohio	Schwind Building
Indianapolis, Ind.	Traction Terminal Building
Knoxville, Tenn.	Bank & Trust Building
Louisville, Ky.	Starks Building
Memphis, Tenn.	Randolph Building
Nashville, Tenn.	Stahlman Building
Toledo, Ohio	Spitzer Building
DENVER, COLO.	First National Bank Building
Boise, Idaho	Idaho Building
Salt Lake City, Utah	Newhouse Building
NEW YORK, N. Y.	30 Church Street
Buffalo, N. Y.	Electric Building
Elmira, N. Y.	Hulett Building
Erie, Pa.	Marine National Bank Building
Hartford, Conn.	Hartford National Bank Building
New Haven, Conn.	Second National Bank Building
Rochester, N. Y.	Granite Building
Syracuse, N. Y.	Onondaga County Savings Bank Building
PHILADELPHIA, PA.	Witherspoon Building
Baltimore, Md.	Electrical Building
Charleston, W. Va.	Charleston National Bank Building
Charlotte, N. C.	Commercial National Bank Building
Pittsburg, Pa.	Oliver Building
Richmond, Va.	Mutual Building
Washington, D. C.	Evans Building
Youngstown, Ohio	Wick Building
SAN FRANCISCO, CAL.	Rialto Building
Los Angeles, Cal.	124 West Fourth Street
Portland, Ore.	Electric Building
Seattle, Wash.	Colman Building
Spokane, Wash.	Paulsen Building
ST. LOUIS, MO.	Wainwright Building
Joplin, Mo.	Miners' Bank Building
Kansas City, Mo.	Dwight Building
Omaha, Neb.	Union Pacific Building

For TEXAS, OKLAHOMA and ARIZONA Business refer to
Southwest General Electric Co., (Formerly Hobson Electric Co.)

DALLAS, TEX.	1701 N. Market Street
El Paso, Tex.	500-2 San Francisco Street
Houston, Tex.	1114 Franklin Street
Oklahoma City, Okla.	Insurance Building

FOREIGN SALES OFFICES
- Schenectady, N. Y., Foreign Dept.
- New York, N. Y., 30 Church Street
- London, E. C., England, 83 Cannon Street

For all CANADIAN Business refer to
Canadian General Electric Co., Ltd., Toronto, Ont.